

## The **xint** bundle

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Package version: 1.09j (2014/01/09)

```
\input xintexpr.sty
\catcode'\_ 11
% December 7, 2013. Expandably computing a big Fibonacci number
% using TeX+\numexpr+\xintexpr, (c) Jean-François Burnol
\def\Fibonacci #1{%
  \expandafter\Fibonacci_a\expandafter
    {\the\numexpr #1\expandafter}\expandafter
    {\romannumeral0\xintiieval 1\expandafter\relax\expandafter}\expandafter
    {\romannumeral0\xintiieval 1\expandafter\relax\expandafter}\expandafter
    {\romannumeral0\xintiieval 0\expandafter\relax\expandafter}\expandafter
    {\romannumeral0\xintiieval 1\expandafter\relax\expandafter}\expandafter
    {\romannumeral0\xintiieval 0\expandafter\relax\expandafter}\expandafter
    {\romannumeral0\xintiieval 1\relax}%
\def\Fibonacci_a #1{%
  \ifcase #1
    \expandafter\Fibonacci_end_i
  \or
    \expandafter\Fibonacci_end_ii
  \else
    \ifodd #1
      \expandafter\expandafter\expandafter\Fibonacci_b_ii
    \else
      \expandafter\expandafter\expandafter\Fibonacci_b_i
    \fi
  \fi {#1}%
}%
\def\Fibonacci_b_i #1#2#3#4{\expandafter\Fibonacci_a\expandafter
  {\the\numexpr #1/2\expandafter}\expandafter
  {\romannumeral0\xintiieval sqr(#2)+sqr(#3)\expandafter\relax\expandafter}\expandafter
  {\romannumeral0\xintiieval (#2+#4)*#3\expandafter\relax\expandafter}\expandafter
  {\romannumeral0\xintiieval sqr(#3)+sqr(#4)\relax}%
}%
\def\Fibonacci_b_ii #1#2#3#4#5#6#7{\expandafter\Fibonacci_a\expandafter
  {\the\numexpr (#1-1)/2\expandafter}\expandafter
  {\romannumeral0\xintiieval sqr(#2)+sqr(#3)\expandafter\relax\expandafter}\expandafter
  {\romannumeral0\xintiieval (#2+#4)*#3\expandafter\relax\expandafter}\expandafter
  {\romannumeral0\xintiieval sqr(#3)+sqr(#4)\expandafter\relax\expandafter}\expandafter
  {\romannumeral0\xintiieval #2*#5+#3*#6\expandafter\relax\expandafter}\expandafter
  {\romannumeral0\xintiieval #2*#6+#3*#7\expandafter\relax\expandafter}\expandafter
  {\romannumeral0\xintiieval #3*#6+#4*#7\relax}%
}%
\def\Fibonacci_end_i #1#2#3#4#5#6#7{\xintthe#6}%
\def\Fibonacci_end_ii #1#2#3#4#5#6#7{\xinttheiiexpr #2*#6+#3*#7\relax}%
\catcode'\_ 8

% This \Fibonacci macro is designed to compute *one* Fibonacci number, not a
% whole sequence of them. Let's reap the fruits of our work:
\message{F(1250)=\Fibonacci {1250}}
\bye % see subsection 27.22 for some explanations and more.
```

The title page illustrates that **xint** is dedicated to do computations on numbers exceeding the  $\text{\TeX}$  limit of 2147483647 (already 9876543210 and  $F(47)=2971215073$  for example are too big for  $\text{\TeX}$  and  $\varepsilon\text{\TeX}$ ), in an *expandable* way, hence the package macros can be used inside an `\edef` or `\write` for example, as here within `\message`.

What is more important is that they can be nested one within the other, because (1.) each one completely expands under the sole process of repeated expansion of the first token (two expansions suffice), and (2.) the package macros (dealing with computations) apply this *f*-expansion to each of their arguments. The `\Fibonacci` macro from this document front page is *f*-expandable (although not in only two steps but this does not matter), thus if we are interested in knowing how many digits  $F(1250)$  has, suffices to use `\xintLen {\Fibonacci {1250}}` (which expands to 261), or if we want to check the formula  $\gcd(F(1859), F(1573))=F(\gcd(1859, 1573))=F(143)$ , we only need<sup>1</sup>

```
\xintGCD{\Fibonacci{1859}}{\Fibonacci{1573}}=\Fibonacci{\xintGCD{1859}{1573}}
343358302784187294870275058337=343358302784187294870275058337
```

The `\Fibonacci` macro expanded its `\xintGCD{...}` argument via the services of `\numexpr`: this step requires something obeying the  $\text{\TeX}$  bound, naturally! (but  $F(2147483648)$  would be rather big anyhow...). À propos, the  $\varepsilon\text{\TeX}$  extensions must be enabled for **xint**, this is the case by default except if you invoke  $\text{\TeX}$  under the name `tex` in command line (`etex` should be used then, or `pdftex` in DVI output mode).

Computations with 100 or 200 digits are still reasonably fast, but the situation then deteriorates swiftly, it takes of the order of seconds for the package to multiply exactly two numbers each of 1000 digits and it would take hours for numbers each of 20000 digits. Perhaps some faster routines could emerge from an approach which, while maintaining expandability would renounce at *f*-expandability (without impacting the input save stack). There is one such routine `\xintXTrunc` which is able to write to a file (or inside an `\edef`) tens of thousands of digits of a (reasonably-sized) fraction.

There is also the possibility to use “Float” routines, although no attempt has been made to implement float-standards such as NaNs, apart from certifying exact rounding for the basic operations (the only non-algebraic operation currently implemented is square root extraction). I doubt one could do the following on a pocket calculator:

$$(1.1547)^{2^{35}} = (1.1547)^{34359738368} \approx \text{\xintFloatPower [48] {1.1547}}{\text{\xintiiPow {2}{35}}}$$

$$= 2.785, 837, 382, 571, 371, 438, 495, 789, 880, 733, 698, 213, 205, 183, 990, 48 \times 10^{2, 146, 424, 193}$$

Notice that  $2^{35}$  exceeds  $\text{\TeX}$ ’s bound, but `\xintFloatPower` allows it, what counts is the exponent of the result which, while dangerously close to  $2^{31}$  is not quite there yet. The printing of the result was done via the `\numprint` command from the `numprint` package<sup>2</sup>.

When producing very long numbers there is the question of printing them on the page, without going beyond the page limits. In this document, I have most of the time made use of these macros (not provided by the package:)

```
\def\allowssplits #1{\ifx #1\relax \else #1\hskip 0pt plus 1pt\relax
\expandafter\allowssplits\fi}%
\def\printnumber #1{\expandafter\allowssplits \romannumeral-‘0#1\relax}%
% \printnumber first ‘fully’ expands its argument.
```

An alternative (footnote 11) is to suitably configure the thousand separator with the `numprint` package (does not work in math mode; I also tried `siunitx` but even in text mode could not get it to break numbers accross lines). Recently I became aware of the `seqsplit` package<sup>3</sup> which can be used to achieve this splitting accross lines, and does work in inline math mode.

<sup>1</sup> The `\xintGCD` macro is provided by the **xintgcd** package. <sup>2</sup> <http://ctan.org/pkg/numprint>  
<sup>3</sup> <http://ctan.org/pkg/seqsplit>

## Description of the packages

**xinttools** is loaded by **xint** (hence by all other packages of the bundle, too): it provides utilities of independent interest such as expandable and non-expandable loops.

**xint** implements with expandable  $\TeX$  macros additions, subtractions, multiplications, divisions and powers with arbitrarily long numbers.

**xintfrac** extends the scope of **xint** to decimal numbers, to numbers in scientific notation and also to fractions with arbitrarily long such numerators and denominators separated by a forward slash.

**xintexpr** extends **xintfrac** with an expandable parser `\xintexpr . . . \relax` of expressions involving arithmetic operations in infix notation on decimal numbers, fractions, numbers in scientific notation, with parentheses, factorial symbol, function names, comparison operators, logic operators, twofold and threefold way conditionals, sub-expressions, macros expanding to the previous items.

Further modules:

**xintbinhex** is for conversions to and from binary and hexadecimal bases.

**xintseries** provides some basic functionality for computing in an expandable manner partial sums of series and power series with fractional coefficients.

**xintgcd** implements the Euclidean algorithm and its typesetting.

**xintcfrac** deals with the computation of continued fractions.

Most macros, and all of those doing computations, work purely by expansion without assignments, and may thus be used almost everywhere in  $\TeX$ .

The packages may be used with any flavor of  $\TeX$  supporting the  $\varepsilon$ - $\TeX$  extensions.  $\LaTeX$  users will use `\usepackage` and others `\input` to load the package components.

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## 1 Quick introduction

The `xint` bundle consists of the three principal components `xint`, `xintfrac` (which loads `xint`), and `xintexpr` (which loads `xintfrac`), and four additional modules. Release 1.09g has moved the macros of `xint` not dealing with the manipulation of big numbers to a separate package `xinttools` (which is automatically loaded by `xint`), of independent interest.

All components may be used as regular packages with  $\text{\LaTeX}$  or loaded directly via `\input` (e.g. `\input xint.sty\relax`) in any other format based on  $\text{\TeX}$ . Each of them automatically loads those not already loaded it depends on.

The  $\varepsilon\text{-TeX}$  extensions must be enabled; this is the case in modern distributions by default, except if you invoke  $\text{\TeX}$  under the name `tex` in command line (`etex` should be used then, or `pdftex` in DVI output mode).

The goal is to compute *exactly*, purely by expansion, without count registers nor assignments nor definitions, with arbitrarily big numbers and fractions. The only non-algebraic operation which is currently implemented is the extraction of square roots.

The package macros expand their arguments<sup>4</sup>; as they are themselves completely expandable, this means that one may nest them arbitrarily deep to construct complicated (and

<sup>4</sup> see in [section 8](#) the related explanations.

still completely expandable) formulas. But one will presumably prefer to use the (expandable!) `\xintexpr` ... `\relax` parser as it allows infix notations, function names (corresponding to some of the package macros), comparison operators, boolean operators, 2way and 3way conditionals, unpacking of count and dimen registers or variables...

## 2 Interesting illustrations

The utilities provided by **xinttools** (section 27), some completely expandable, others not, are of independent interest. Their use is illustrated through various examples: among those, it is shown in subsection 27.28 how to implement in a completely expandable way the **Quick Sort algorithm** and also how to illustrate it graphically. Other examples include some dynamically constructed alignments with automatically computed prime number cells: one using a completely expandable prime test and `\xintApplyUnbraced` (subsection 27.11), another one with `\xintFor*` (subsection 27.21).

One has also a **computation of primes within an \edef** (subsection 27.13), with the help of `\xintiloop`. Also with `\xintiloop` an **automatically generated table of factorizations** (subsection 27.15).

The title page fun with Fibonacci numbers is continued in subsection 27.22 with `\xintFor*` joining the game,.

The computations of  $\pi$  and  $\log 2$  (subsection 33.11) using **xint** and the computation of the **convergents of  $e$**  with the further help of the **xintcfrac** package are among further examples.

There is also an example of an **interactive session**, where results are output to the log or to a file.

## 3 Recent changes

Release 1.09j ([2014/01/09])

- The core division routines have been re-written for some (limited) efficiency gain, more pronounced for small divisors. As a result the **computation of one thousand digits of  $\pi$**  is close to three times faster than with earlier releases.
- Some various other small improvements, particularly in the power routines.
- A new macro `\xintXTrunc` is designed to produce thousands or even tens of thousands of digits of the decimal expansion of a fraction. Although completely expandable it has its use limited to inside an `\edef`, `\write`, `\message`, .... It can thus not be nested as argument to another package macro.
- the tacit multiplication done in `\xintexpr`...`\relax` on encountering a count register or variable, or a `\numexpr`, while scanning a (decimal) number, is extended to the case of a sub `\xintexpr`-ession.
- `\xintexpr` can now be used in an `\edef` with no `\xintthe` prefix; it will execute completely the computation, and the error message about a missing `\xintthe` will be inhibited. Previously, in the absence of `\xintthe`, expansion could only be a full one (with `\romannumeral-‘0`), not a complete one (with `\edef`). Note that this differs from the behavior of the non-expandable `\numexpr`: `\the` or `\number` are needed not only to print but also to trigger the computation, whereas `\xintthe` is mandatory only for the printing step.
- the default behavior of `\xintAssign` is changed, it now does not do any further expansion beyond the initial full-expansion which provided the list of items to be assigned to macros.
- bug-fix: 1.09i did an unexplainable change to `\XINT_infloat_zero` which broke the floating point routines for vanishing operands `:=(((`

### 3 Recent changes

- dtx bug-fix: the 1.09i .ins file produced a buggy .tex file.

For a more detailed change history, see [section 26](#). Main recent additions:

Release 1.09i ([2013/12/18]):

- `\xintiexpr` is a variant of `\xintexpr` which is optimized to deal only with (long) integers, / does a euclidean quotient.
- `\xintnumexpr`, `\xintthenumexpr`, `\xintNewNumExpr` are renamed, respectively, `\xintiexpr`, `\xint-theiexpr`, `\xintNewIExpr`. The earlier denominations are kept but to be removed at some point.
- it is now possible within `\xintexpr... \relax` and its variants to use count, dimen, and skip registers or variables without explicit `\the/\number`: the parser inserts automatically `\number` and a tacit multiplication is implied when a register or variable immediately follows a number or fraction.
- `xinttools` defines `\odef`, `\oodef`, `\fdef`. These tools are provided for the case one uses the package macros in a non-expandable context, particularly `\oodef` which expands twice the macro replacement text and is thus a faster alternative to `\edef`. This can be significant when repeatedly making `\def`initions expanding to hundreds of digits.

Release 1.09h ([2013/11/28]):

- all macros of `xinttools` for which it makes sense are now declared `\long`.

Release 1.09g ([2013/11/22]):

- package `xinttools` is detached from `xint`, to make tools such as `\xintFor`, `\xintApplyUnbraced`, and `\xintilop` available without the `xint` overhead.
- new expandable nestable loops `\xintloop` and `\xintilop`.

Release 1.09f ([2013/11/04]):

- new `\xintZapFirstSpaces`, `\xintZapLastSpaces`, `\xintZapSpaces`, `\xintZapSpacesB`, for expandably stripping away leading and/or ending spaces.
- `\xintCSVtoList` by default uses `\xintZapSpacesB` to strip away spaces around commas (or at the start and end of the comma separated list).
- also the `\xintFor` loop will strip out all spaces around commas and at the start and the end of its list argument; and similarly for `\xintForpair`, `\xintForthree`, `\xintForfour`.
- `\xintFor` *et al.* accept all macro parameters from #1 to #9.

Release 1.09e ([2013/10/29]):

- new `\xintintegers`, `\xintdimensions`, `\xintrationals` for infinite `\xintFor` loops, interrupted with `\xintBreakFor` and `\xintBreakForAndDo`.
- new `\xintifForFirst`, `\xintifForLast` for the `\xintFor` and `\xintFor*` loops,
- the `\xintFor` and `\xintFor*` loops are now `\long`, the replacement text and the items may contain explicit `\par`'s.
- new conditionals `\xintifCmp`, `\xintifInt`, `\xintifOdd`.
- the documentation has been enriched with various additional examples, such as the [the quick sort algorithm illustrated](#) or the computation of prime numbers ([subsection 27.11](#), [subsection 27.14](#), [subsection 27.21](#)).

Release 1.09c ([2013/10/09]):

- added `bool` and `togl` to the `\xintexpr` syntax; also added `\xintboolexpr` and `\xintifboolexpr`.
- `\xintFor` is a new type of loop, whose replacement text inserts the comma separated values or list items via macro parameters, rather than encapsulated in macros; the loops are nestable up to four levels (nine levels since 1.09f), and their replacement texts are allowed to close groups as happens with the tabulation in alignments,
- `\xintApplyInline` has been enhanced in order to be usable for generating rows (partially or completely) in an alignment,
- new command `\xintSeq` to generate (expandably) arithmetic sequences of (short) integers,

Release 1.09a ([2013/09/24]):

## 4 Overview

- `\xintexpr..relax` and `\xintfloatexpr..relax` admit functions in their syntax, with comma separated values as arguments, among them `reduce`, `sqr`, `sqrt`, `abs`, `sgn`, `floor`, `ceil`, `quo`, `rem`, `round`, `trunc`, `float`, `gcd`, `lcm`, `max`, `min`, `sum`, `prd`, `add`, `mul`, `not`, `all`, `any`, `xor`.
- comparison (`<`, `>`, `=`) and logical (`|`, `&`) operators.
- `\xintNewExpr` now works with the standard macro parameter character `#`.
- both regular `\xintexpr`-essions and commands defined by `\xintNewExpr` will work with comma separated lists of expressions,
- new commands `\xintFloor`, `\xintCeil`, `\xintMaxof`, `\xintMinof` (package `xintfrac`), `\xintGCDof`, `\xintLCM`, `\xintLCMof` (package `xintgcd`), `\xintifLt`, `\xintifGt`, `\xintifSgn`, `\xintANDof`, ...
- The arithmetic macros from package `xint` now filter their operands via `\xintNum` which means that they may use directly count registers and `\numexpr`-essions without having to prefix them by `\the`. This is thus similar to the situation holding previously but with `xintfrac` loaded.

See [section 26](#) for more.

## 4 Overview

The main characteristics are:

1. exact algebra on arbitrarily big numbers, integers as well as fractions,
2. floating point variants with user-chosen precision,
3. implemented via macros compatible with expansion-only context.

‘Arbitrarily big’: this means with less than  $2^{31}-1=2147483647$  digits, as most of the macros will have to compute the length of the inputs and these lengths must be treatable as  $\text{\TeX}$  integers, which are at most 2147483647 in absolute value. This is a distant irrelevant upper bound, as no such thing can fit in  $\text{\TeX}$ ’s memory! And besides, the true limitation is from the *time* taken by the expansion-compatible algorithms, as will be commented upon soon.

As just recalled, ten-digits numbers starting with a 3 already exceed the  $\text{\TeX}$  bound on integers; and  $\text{\TeX}$  does not have a native processing of floating point numbers (multiplication by a decimal number of a dimension register is allowed — this is used for example by the `pgf` basic math engine.)

$\text{\TeX}$  elementary operations on numbers are done via the non-expandable *advance*, *multiply*, and *divide* assignments. This was changed with  $\varepsilon\text{-}\text{\TeX}$ ’s `\numexpr` which does expandable computations using standard infix notations with  $\text{\TeX}$  integers. But  $\varepsilon\text{-}\text{\TeX}$  did not modify the  $\text{\TeX}$  bound on acceptable integers, and did not add floating point support.

The `bigintcalc` package by HEIKO OBERDIEK provided expandable operations (using some of `\numexpr` possibilities, when available) on arbitrarily big integers, beyond the  $\text{\TeX}$  bound. The present package does this again, using more of `\numexpr` (`xint` requires the  $\varepsilon\text{-}\text{\TeX}$  extensions) for higher speed, and also on fractions, not only integers. Arbitrary precision floating points operations are a derivative, and not the initial design goal.<sup>5, 6</sup>

---

<sup>5</sup> currently (v1.08), the only non-elementary operation implemented for floating point numbers is the square-root extraction; furthermore no NaN’s nor error traps has been implemented, only the notion of ‘scientific notation with a given number of significant figures’. <sup>6</sup> multiplication of two floats with  $P=\text{\code\xinttheDigits}$  digits is first done exactly then rounded to  $P$  digits, rather than using a specially tailored multiplication for floating point numbers which would be more efficient (it is a waste to evaluate fully the multiplication result with  $2P$  or  $2P-1$  digits.)

## 5 Missing things

The L<sup>A</sup>T<sub>E</sub>X3 project has implemented expandably floating-point computations with 16 significant figures ([l3fp](#)), including special functions such as exp, log, sine and cosine.

The [xint](#) package can be used for 24, 40, etc... significant figures but one rather quickly (not much beyond 100 figures perhaps) hits against a ‘wall’ created by the constraint of expandability: currently, multiplying out two one-hundred digits numbers takes circa 80 or 90 times longer than for two ten-digits numbers, which is reasonable, but multiplying out two one-thousand digits numbers takes more than 500 times longer than for two one hundred-digits numbers. This shows that the algorithm is drifting from quadratic to cubic in that range. On my laptop multiplication of two 1000-digits numbers takes some seconds, so it can not be done routinely in a document.<sup>7</sup>

The conclusion perhaps could be that it is in the end lucky that the speed gains brought by [xint](#) for expandable operations on big numbers do open some non-empty range of applicability in terms of the number of kept digits for routine floating point operations.

The second conclusion, somewhat depressing after all the hard work, is that if one really wants to do computations with *hundreds* of digits, one should drop the expandability requirement. And indeed, as clearly demonstrated long ago by the [pi computing file](#) by D. ROEGEL one can program T<sub>E</sub>X to compute with many digits at a much higher speed than what [xint](#) achieves: but, direct access to memory storage in one form or another seems a necessity for this kind of speed and one has to renounce at the complete expandability.<sup>8 9</sup>

## 5 Missing things

‘Arbitrary-precision’ floating-point operations are currently limited to the basic four operations, the power function with integer exponent, and the extraction of square-roots.

## 6 Some examples

The main initial goal is to allow computations with integers and fractions of arbitrary sizes.

Here are some examples. The first one uses only the base module [xint](#), the next two require the [xintfrac](#) package, which deals with fractions. Then two examples with the [xintgcd](#) package, one with the [xintseries](#) package, and finally a computation with a float. Some inputs are simplified by the use of the [xintexpr](#) package.

[123456](#)<sup>99</sup>:

```
\xintiPow{123456}{99}: 11473818116626655663327333000845458674702548042
34261029758895454373590894697032027622647054266320583469027086822116
81334152500324038762776168953222117634295872033762216088606915850757
16801971671071208769703353650737748777873778498781606749999798366581
```

<sup>7</sup> without entering into too much technical details, the source of this ‘wall’ is that when dealing with two long operands, when one wants to pick some digits from the second one, one has to jump above all digits constituting the first one, which can not be stored away: expandability forbids assignments to memory storage. One may envision some sophisticated schemes, dealing with this problem in less naive ways, trying to move big chunks of data higher up in the input stream and come back to it later, etc...; but each ‘better’ algorithm adds overhead for the smaller inputs. For example, I have another version of addition which is twice faster on inputs with 500 digits or more, but it is slightly less efficient for 50 digits or less. This ‘wall’ dissuaded me to look into implementing ‘intelligent’ multiplication which would be sub-quadratic in a model where storing and retrieving from memory do not cost much. <sup>8</sup> I could, naturally, be proven wrong! <sup>9</sup> The LuaT<sub>E</sub>X project possibly makes endeavours such as [xint](#) appear even more insane that they are, in truth.

## 6 Some examples

25172327521549705416595667384911533326748541075607669718906235189958  
32377826369998110953239399323518999222056458781270149587767914316773  
54372538584459487155941215197416398666125896983737258716757394949435  
52017095026186580166519903071841443223116967837696

1234/56789 with 1500 digits after the decimal point:

```
\xintTrunc{1500}{1234/56789}\dots: 0.021729560302171195125816619415731
91991406786525559527373258905774005529239817570304108189966366725950
44815016992727464825934600010565426403000581098452165031960414869076
75782281779922168025497895719241402384264558277131134550705242212400
28878832168201588335769251087358467308809804715701984539259363609149
65926499850323125957491767771927662047227456021412597510081177692863
05446477310746799556252091073975593865009068657662575498776171441652
43268942929088379791861099860888552360492348870379827079187870890489
35533289897691454330944373029988201940516649351106728415714310870062
86428709785345753579038194016446847100670904576590536899751712479529
48634418637412174893025057669619116378171829051400799450597827043969
78288048741833805842680800859321347444047262674109422599447076018242
96958918100336332740495518498300727253517406539998943457359699941890
15478349680395851309232421771822007783197450210428075859761573544172
28688654492947577875997112116783179841166423074891264153269119019528
42980154607406363908503407350014967687404250823222807233795277254397
85874024899188223071369455352268925320044374790892602440613499093134
23374245012238285583475673105707091162020813890013911144763950765112
96201729208121291095106446671010230854566905562697001179805948335064
88932715842856891299371357129021465424642096180598355315289932909542
34094631002482875204705136558136258782510697494233038088362182817094
85992005494021729560302171195125816619415731919914067865255595273732
589057740055292398175703041081899663667...
```

$0.99^{-100}$  with 200 digits after the decimal point:

```
\xinttheexpr trunc(.99^-100,200)\relax\dots: 2.731999026429026003846671
72125783743550535164293857207083343057250824645551870534304481430137
84806140368055624765019253070342696854891531946166122710159206719138
4034885148574794308647096392073177979303...
```

Computation of a Bezout identity with  $7^{200}-3^{200}$  and  $2^{200}-1$ :

```
\xintAssign \xintBezout {\xinttheiexpr 7^200-3^200\relax}
{\xinttheiexpr 2^200-1\relax}\to\A\B\U\V\D
\U$\times$(7^200-3^200)+\xintiOpp\V$\times$(2^200-1)=\D
-220045702773594816771390169652074193009609478853\times(7^200-3^200)+1432
58949362763693185913068326832046547441686338771408915838167247899192
11328201191274624371580391777549768571912876931442406050669914563361
43205677696774891\times(2^200-1)=1803403947125
```

The Euclidean algorithm applied to 22,206,980,239,027,589,097 and 8,169,486,210,102,119,256.<sup>10</sup>

```
\xintTypesetEuclideanAlgorithm {22206980239027589097}{8169486210102119256}
22206980239027589097 = 2 \times 8169486210102119256 + 5868007818823350585
```

<sup>10</sup> this example is computed tremendously faster than the other ones, but we had to limit the space taken by the output.

## 6 Some examples

$$\begin{aligned}
 8169486210102119256 &= 1 \times 5868007818823350585 + 2301478391278768671 \\
 5868007818823350585 &= 2 \times 2301478391278768671 + 1265051036265813243 \\
 2301478391278768671 &= 1 \times 1265051036265813243 + 1036427355012955428 \\
 1265051036265813243 &= 1 \times 1036427355012955428 + 228623681252857815 \\
 1036427355012955428 &= 4 \times 228623681252857815 + 121932630001524168 \\
 228623681252857815 &= 1 \times 121932630001524168 + 106691051251333647 \\
 121932630001524168 &= 1 \times 106691051251333647 + 15241578750190521 \\
 106691051251333647 &= 7 \times 15241578750190521 + 0
 \end{aligned}$$

$\sum_{n=1}^{500} (4n^2 - 9)^{-2}$  with each term rounded to twelve digits, and the sum to nine digits:  
`\def\coeff #1%`

`{\xintiRound {12}{1/\xintiSqr{\the\numexpr 4*#1*#1-9\relax }[0]}}`  
`\xintRound {9}{\xintiSeries {1}{500}{\coeff}[-12]}: 0.062366080`

The complete series, extended to infinity, has value  $\frac{\pi^2}{144} - \frac{1}{162} = 0.062,366,079,945,836,595,346,844,45\dots$ <sup>11</sup> I also used (this is a lengthier computation than the one above) `xintseries` to evaluate the sum with 100,000 terms, obtaining 16 correct decimal digits for the complete sum. The coefficient macro must be redefined to avoid a `\numexpr` overflow, as `\numexpr` inputs must not exceed  $2^{31}-1$ ; my choice was:

`\def\coeff #1%`  
`{\xintiRound {22}{1/\xintiSqr{\xintiMul{\the\numexpr 2*#1-3\relax}`  
`{\the\numexpr 2*#1+3\relax}}[0]}}`

Computation of  $2^{999,999,999}$  with 24 significant figures:

`\numprint{\xintFloatPow [24] {2}{999999999}}` expands to:  
 $2.306,488,000,584,534,696,558,06 \times 10^{301,029,995}$

where the `\numprint` macro from the [eponym package](#) was used.

As an example of chaining package macros, let us consider the following code snippet within a file with filename `myfile.tex`:

`\newwrite\outstream`  
`\immediate\openout\outstream \jobname-out\relax`  
`\immediate\write\outstream {\xintQuo{\xintPow{2}{1000}}{\xintFac{100}}}`  
`% \immediate\closeout\outstream`

The tex run creates a file `myfile-out.tex`, and then writes to it the quotient from the euclidean division of  $2^{1000}$  by  $100!$ . The number of digits is `\xintLen{\xintQuo{\xintPow{2}{1000}}{\xintFac{100}}}` which expands (in two steps) and tells us that  $[2^{1000}/100!]$  has 144 digits. This is not so many, let us print them here: 114813249641507505482278393872551066259805517784186172883663478065826541894704737970419535798876630484358265060061503749531707793118627774829601.

For the sake of typesetting this documentation and not have big numbers extend into the margin and go beyond the page physical limits, I use these commands (not provided by the package):

`\def\allowsplits #1{\ifx #1\relax \else #1\hskip 0pt plus 1pt \relax`  
`\expandafter\allowsplits\fi}%`  
`\def\printnumber #1{\expandafter\expandafter\expandafter`  
`\allowsplits #1\relax }%`

<sup>11</sup> This number is typeset using the `numprint` package, with `\npthousandsep {,\hskip 1pt plus .5pt minus .5pt}`. But the breaking across lines works only in text mode. The number itself was (of course...) computed initially with `xint`, with 30 digits of  $\pi$  as input. See [how xint may compute  \$\pi\$  from scratch](#).

## 7 Origins of the package

% Expands twice before printing.

The `\printnumber` macro is not part of the package and would need additional thinking for more general use.<sup>12</sup> It may be used as `\printnumber {\xintQuo{\xintPow {2}{1000}}{\xintFac{100}}}`, or as `\printnumber\mynumber` if the macro `\mynumber` was previously defined via an `\edef`, as for example:

`\edef\mynumber {\xintQuo {\xintPow {2}{1000}}{\xintFac{100}}}`  
or as `\expandafter\printnumber\expandafter{\mynumber}`, if the macro `\mynumber` is defined by a `\newcommand` or a `\def`; using seven rather than three `\expandafter`’s in `\printnumber` would allow to use it directly as `\printnumber\mynumber` when `\mynumber` has been defined via a `\def` or `\newcommand` using a chain of package macros.

Just to show off (again), let’s print 300 digits (after the decimal point) of the decimal expansion of  $0.7^{-25}$ :<sup>13</sup>

```
\np {\xinttheexpr trunc(.7^-25,300)\relax}\dots
7,456.739,985,837,358,837,609,119,727,341,853,488,853,339,101,579,533,
584,812,792,108,394,305,337,246,328,231,852,818,407,506,767,353,741,
490,769,900,570,763,145,015,081,436,139,227,188,742,972,826,645,967,
904,896,381,378,616,815,228,254,509,149,848,168,782,309,405,985,245,
368,923,678,816,256,779,083,136,938,645,362,240,130,036,489,416,562,
067,450,212,897,407,646,036,464,074,648,484,309,937,461,948,589...
```

This computation is with `\xinttheexpr` from package `xintexpr`, which allows to use standard infix notations and function names to access the package macros, such as here `trunc` which corresponds to the `xintfrac` macro `\xintTrunc`. The fraction  $.7^{-25}$  is first evaluated *exactly*; for some more complex inputs, such as  $.7123045678952^{-243}$ , the exact evaluation before truncation would be expensive, and (assuming one needs twenty digits) one would rather use floating mode:

```
\xintDigits:=20; \np{\xintthefloatexpr .7123045678952^-243\relax}
.7123045678952^-243 ≈ 6.342,022,117,488,416,127,3 × 1035
```

The exponent  $-243$  didn’t have to be put inside parentheses, contrarily to what happens with some professional computational software.

To see more of `xint` in action, jump to the [section 33](#) describing the commands of the `xintseries` package, especially as illustrated with the [traditional computations of  \$\pi\$  and  \$\log 2\$](#) , or also see the [computation of the convergents of  \$e\$](#)  made with the `xintfrac` package.

Almost all of the computational results interspersed through the documentation are not hard-coded in the source of the document but just written there using the package macros, and were selected to not impact too much the compilation time.

## 7 Origins of the package

Package `bigintcalc` by HEIKO OBERDIEK already provides expandable arithmetic operations on “big integers”, exceeding the  $\text{T}_{\text{E}}\text{X}$  limits (of  $2^{\{31\}}-1$ ), so why another<sup>14</sup> one?

<sup>12</sup> as explained in [a previous footnote](#), the `numprint` package may also be used, in text mode only (as the thousand separator seemingly ends up typeset in a `\hbox` when in math mode). <sup>13</sup> the `\np` typesetting macro is from the `numprint` package. <sup>14</sup> this section was written before the `xintfrac` package; the author is not aware of another package allowing expandable computations with arbitrarily big fractions.

I got started on this in early March 2013, via a thread on the `c.t.tex` usenet group, where ULRICH DIEZ used the previously cited package together with a macro (`\ReverseOrder`) which I had contributed to another thread.<sup>15</sup> What I had learned in this other thread thanks to interaction with ULRICH DIEZ and GL on expandable manipulations of tokens motivated me to try my hands at addition and multiplication.

I wrote macros `\bigMul` and `\bigAdd` which I posted to the newsgroup; they appeared to work comparatively fast. These first versions did not use the  $\varepsilon$ - $\text{\TeX}$  `\numexpr` primitive, they worked one digit at a time, having previously stored carry-arithmetic in 1200 macros.

I noticed that the `bigintcalc` package used `\numexpr` if available, but (as far as I could tell) not to do computations many digits at a time. Using `\numexpr` for one digit at a time for `\bigAdd` and `\bigMul` slowed them a tiny bit but avoided cluttering  $\text{\TeX}$  memory with the 1200 macros storing pre-computed digit arithmetic. I wondered if some speed could be gained by using `\numexpr` to do four digits at a time for elementary multiplications (as the maximal admissible number for `\numexpr` has ten digits).

The present package is the result of this initial questioning.

## 8 Expansions

By convention in this manual *f*-expansion (“full expansion” or “full first expansion”) is the process of expanding repeatedly the first token seen until hitting against something not further expandable like an unexpandable  $\text{\TeX}$ -primitive or an opening brace `{` or a character (inactive). For those familiar with  $\text{\LaTeX}$ 3 (which is not used by **xint**) this is what is called in its documentation full expansion. Technically, macro arguments in **xint** which are submitted to such a *f*-expansion are so via prefixing them with `\romannumeral-‘0`. An explicit or implicit space token stops such an expansion and is gobbled.

Most of the package macros, and all those dealing with computations, are expandable in the strong sense that they expand to their final result via this *f*-expansion. Again copied from  $\text{\LaTeX}$ 3 documentation conventions, this will be signaled in the description of the macro by a star in the margin. All<sup>16</sup> expandable macros of the **xint** packages completely expand in two steps.

Furthermore the macros dealing with computations, as well as many utilities from **xinttools**, apply this process of *f*-expansion to their arguments. Again from  $\text{\LaTeX}$ 3’s conventions this will be signaled by a margin annotation. Some additional parsing which is done by most macros of **xint** is indicated with a variant; and the extended fraction parsing done by most macros of **xintfrac** has its own symbol. When the argument has a priori to obey the  $\text{\TeX}$  bound of 2147483647 it is systematically fed to a `\numexpr`. `\relax` hence the expansion is then a *complete* one, signaled with an *x* in the margin. This means not only complete expansion, but also that spaces are ignored, infix algebra is possible, count registers are allowed, etc. . .

*\*f* The `\xintApplyInline` and `\xintFor*` macros from **xinttools** apply a special iterated *f*-expansion, which gobbles spaces, to all those items which are found *unbraced* from left to right in the list argument; this is denoted specially as here in the margin. Some other macros such as `\xintSum` from **xintfrac** first do an *f*-expansion, then treat each found (braced or not) item (skipping spaces between such items) via the general fraction input

<sup>15</sup> the `\ReverseOrder` could be avoided in that circumstance, but it does play a crucial rôle here.

<sup>16</sup> except `\xintloop` and `\xintilloop`.

parsing, this is signaled as here in the margin where the signification of the `*` is thus a bit different from the previous case.

*n*, resp. *o* A few macros from **xinttools** do not expand, or expand only once their argument. This is also signaled in the margin with notations à la L<sup>A</sup>T<sub>E</sub>X3.

As the computations are done by *f*-expandable macros which *f*-expand their argument they may be chained up to arbitrary depths and still produce expandable macros.

Conversely, wherever the package expects on input a “big” integers, or a “fraction”, *f*-expansion of the argument *must result in a complete expansion* for this argument to be acceptable.<sup>17</sup> The main exception is inside `\xintexpr... \relax` where everything will be expanded from left to right, completely.

Summary of important expansion aspects:

1. the macros *f*-expand their arguments, this means that they expand the first token seen (for each argument), then expand, etc..., until something un-expandable such as a digit or a brace is hit against. This example

```
\def\x{98765}\def\y{43210}\xintAdd {\x}{\x\y}
```

is *not* a legal construct, as the `\y` will remain untouched by expansion and not get converted into the digits which are expected by the sub-routines of `\xintAdd`. It is a `\numexpr` which will expand it and an arithmetic overflow will arise as 9876543210 exceeds the T<sub>E</sub>X bounds.

With `\xinttheexpr` one could write `\xinttheexpr \x+\x\y\relax`, or `\xintAdd \x{\xinttheexpr\x\y\relax}`.

2. using `\if... \fi` constructs *inside* the package macro arguments requires suitably mastering T<sub>E</sub>Xniques (`\expandafter`’s and/or swapping techniques) to ensure that the *f*-expansion will indeed absorb the `\else` or closing `\fi`, else some error will arise in further processing. Therefore it is highly recommended to use the package provided conditionals such as `\xintifEq`, `\xintifGt`, `\xintifSgn`, `\xint-ifOdd...`, or, for L<sup>A</sup>T<sub>E</sub>X users and when dealing with short integers the **etoolbox**<sup>18</sup> expandable conditionals (for small integers only) such as `\ifnumequal`, `\ifnumgreater`, .... Use of *non-expandable* things such as `\ifthenelse` is impossible inside the arguments of **xint** macros.

One can use naive `\if... \fi` things inside an `\xinttheexpr`-ession and cousins, as long as the test is expandable, for example

```
\xinttheiexpr\ifnum3>2 143\else 33\fi 0^2\relax→2044900=1430^2
```

3. after the definition `\def\x {12}`, one can not use `-\x` as input to one of the package macros: the *f*-expansion will act only on the minus sign, hence do nothing. The only way is to use the `\xintOpp` macro, or perhaps here rather `\xintiOpp` which does maintains integer format on output, as they replace a number with its opposite.

Again, this is otherwise inside an `\xinttheexpr`-ession or `\xintthefloatexpr`-ession. There, the minus sign may prefix macros which will expand to numbers (or parentheses etc...)

4. With the definition

```
\def\AplusBC #1#2#3{\xintAdd {#1}{\xintMul {#2}{#3}}}
```

<sup>17</sup> this is not quite as stringent as claimed here, see [section 12](#) for more details.

<sup>18</sup> <http://www.ctan.org/pkg/etoolbox>

one obtains an expandable macro producing the expected result, not in two, but rather in three steps: a first expansion is consumed by the macro expanding to its definition. As the package macros expand their arguments until no more is possible (regarding what comes first), this `\AplusBC` may be used inside them: `\xintAdd {\AplusBC {1}{2}{3}}{4}` does work and returns 11/1 [0].

If, for some reason, it is important to create a macro expanding in two steps to its final value, one may either do:

```
\def\AplusBC #1#2#3{\romannumeral-‘0\xintAdd {#1}{\xintMul {#2}{#3}}}
```

or use the *lowercase* form of `\xintAdd`:

```
\def\AplusBC #1#2#3{\romannumeral0\xintadd {#1}{\xintMul {#2}{#3}}}
```

and then `\AplusBC` will share the same properties as do the other **xint** ‘primitive’ macros.

The `\romannumeral0` and `\romannumeral-‘0` things above look like an invitation to hacker’s territory; if it is not important that the macro expands in two steps only, there is no reason to follow these guidelines. Just chain arbitrarily the package macros, and the new ones will be completely expandable and usable one within the other.

Since release 1.07 the `\xintNewExpr` command automatizes the creation of such expandable macros:

```
\xintNewExpr\AplusBC[3]{#1+#2*#3}
```

creates the `\AplusBC` macro doing the above and expanding in two expansion steps.

## 9 Input formats

The core bundle constituents are **xint**, **xintfrac**, **xintexpr**, each one loading its predecessor. The base constituent **xint** only handles (big) integers, and **xintfrac** additionally manages decimal numbers, numbers in scientific notation, and fractions. Both load **xint-tools** which provides utilities not directly related to big numbers.

The package macros first *f*-expand their arguments: the first token of the argument is repeatedly expanded until no more is possible.

For those arguments which are constrained to obey the  $\text{\TeX}$  bounds on numbers, they are systematically inserted inside a `\numexpr... \relax` expression, hence the expansion is then a complete one.

The allowed input formats for ‘long numbers’ and ‘fractions’ are:

- f* 1. the strict format is for some macros of **xint** which only *f*-expand their arguments. After this *f*-expansion the input should be a string of digits, optionally preceded by a unique minus sign. The first digit can be zero only if the number is zero. A plus sign is not accepted. `-0` is not legal in the strict format.
2. the macro `\xintNum` normalizes into strict format an input having arbitrarily many minus and plus signs, followed by a string of zeros, then digits:

```
\xintNum {+---+-----+---+---00000000009876543210}=-9876543210
```

The extended integer format is thus for the arithmetic macros of **xint** which automatically parse their arguments via this `\xintNum`.

Num  
*f*

Frac  
f

3. the fraction format is what is expected by the macros of **xintfrac**: a fraction is constituted of a numerator A and optionally a denominator B, separated by a forward slash / and A and B may be macros which will be automatically given to `\xintNum`. Each of A and B may be decimal numbers (the decimal mark must be a .). Here is an example:<sup>19</sup>

```
\xintAdd {+--0367.8920280/-++278.289287}{-109.2882/+270.12898}
```

Incidentally this evaluates to

```
=-129792033529284840/7517400124223726[-1]
```

```
=-6489601676464242/3758700062111863 (irreducible)
```

```
=-1.72655481129771093694248704898677881556360055242806...
```

where the second line was produced with `\xintIrr` and the next with `\xintTrunc{50}` to get fifty digits of the decimal expansion following the decimal mark. Scientific notation is accepted for both numerator and denominator of a fraction, and is produced on output by `\xintFloat`:

```
\xintAdd{10.1e1}{101.010e3}=101111/1[0]
```

```
\xintFloatAdd{10.1e1}{101.010e3}=1.011110000000000e5
```

```
\xintFloat{\xintiPow {2}{100}}=1.267650600228229e30
```

Produced fractions with a denominator equal to one are nevertheless generally printed as fraction. In math mode `\xintFrac` will remove such dummy denominators, and in inline text mode one has `\xintPraw` with the similar effect.

```
\xintPraw{\xintAdd{10.1e1}{101.010e3}}=101111
```

```
\xintRaw{1.234e5/6.789e3}=1234/6789[2]
```

```
\xintFloat[24]{1/66049}=1.51402746445820527184363e-5
```

4. the **expression format** is for inclusion in an `\xintexpr... \relax`, it uses infix notations, function names, complete expansion, and is described in its devoted section (section 25).

Even with **xintfrac** loaded, some macros by their nature can not accept fractions on input. Those parsing their inputs through `\xintNum` will accept a fraction reducing to an integer. For example `\xintQuo {100/2}{12/3}` works, because its arguments are, after simplification, integers. In this documentation, I often say “numbers or fractions”, although at times the vocable “numbers” by itself may also include “fractions”; and “decimal numbers” are counted among “fractions”.

A number can start directly with a decimal point:

```
\xintPow{-.3/.7}{11}=-177147/1977326743[0]
```

```
\xinttheexpr (-.3/.7)^11\relax=-177147/1977326743[0]
```

It is also licit to use `\A/\B` as input if each of `\A` and `\B` expands (in the sense previously described) to a “decimal number” as exemplified above by the numerators and denominators (thus, possibly with a ‘scientific’ exponent part, with a lowercase ‘e’). Or one may have just one macro `\C` which expands to such a “fraction with optional decimal points”, or mixed things such as `\A 245/7.77`, where the numerator will be the concatenation of the expansion of `\A` and 245. But, as explained already `123\A` is a no-go, *except inside an \xintexpr-ession!*

The scientific notation is necessarily (except in `\xintexpr... \relax`) with a lowercase e. It may appear both at the numerator and at the denominator of a fraction.

<sup>19</sup> the square brackets one sees in various outputs are explained near the end of this section.

## 9 Input formats

`\xintRaw {+---+1253.2782e+---3/---0087.123e---5}=-12532782/87123[7]`

Num  
*f*

Arithmetic macros of **xint** which parse their arguments automatically through `\xint-Num` are signaled by a special symbol in the margin. This symbol also means that these arguments may contain to some extent infix algebra with count registers, see the section [Use of count registers](#).

Frac  
*f*

With **xintfrac** loaded the symbol  $\overset{\text{Num}}{f}$  means that a fraction is accepted if it is a whole number in disguise; and for macros accepting the full fraction format with no restriction there is the corresponding symbol in the margin.

Summary of the input formats for the bundle macros dealing with numbers (except `\xintexpr...\relax`):

num  
*x*

1. ‘short’ integers, *i.e.* less than (or equal to) in absolute value 2,147,483,647. I will refer to this as the ‘T<sub>E</sub>X’ or ‘\numexpr’ limit. This is the case for arguments which serve to count or index something. It is also the case for the exponent in the power function and for the argument to the factorial function.<sup>20</sup> When the argument exceeds the T<sub>E</sub>X bound (either positively or negatively), an error will originate from a `\numexpr` expression and it may sometimes be followed by a more specific error ‘message’ from a package macro.

*f*

2. ‘long’ integers in strict format: only one optional minus sign, anything starting with zero is treated as zero. Some macros of **xint** require this format, but most accept the extended format described in the next item; they may then have a ‘strict’ variant for optimizing purposes with a ‘ii’ in their names, this variant remains available even with **xintfrac** loaded. A count register can serve as argument of such a macro only if prefixed by `\the` or `\number`.

Num  
*f*

3. ‘long’ integers automatically parsed by `\xintNum`, they may have leading signs followed by leading zeros, and they may be count registers with no need of being prefixed by `\the` or `\number`.<sup>21</sup> The number of digits must (as in the strict format) be less than 2,147,483,647.

Frac  
*f*

4. ‘fractions’: they become available after having loaded the **xintfrac** package. A fraction has a numerator, a forward slash and then a denominator. Both can use scientific notation (with a lowercase e) and the dot as decimal mark. No separator for thousands. Except within `\xintexpr`-essions, spaces should be avoided.

Regarding fractions, the **xintfrac** macros generally output in `A/B[n]` format, representing the fraction `A/B` times `10^n`.

This format with a trailing `[n]` (possibly, `n=0`) is accepted on input but it presupposes that the numerator and denominator `A` and `B` are in the strict integer format described above. So `16000/289072[17]` or `3[-4]` are authorized and it is even possible to use `\A/\B[17]` if `\A` expands to `16000` and `\B` to `289072`, or `\A` if `\A` expands to `3[-4]`. However, NEITHER the numerator NOR the denominator may then have a decimal point. And, for this format, ONLY the numerator may carry a UNIQUE minus sign (and no superfluous leading zeros; and NO plus sign).

IMPORTANT!

<sup>20</sup> the bound has even been lowered for them but the float power function limits the exponent only to the T<sub>E</sub>X bound, and has a variant with no imposed limit on the exponent; but the result of the computation must in all cases be representable with a power of ten exponent obeying the T<sub>E</sub>X bound. <sup>21</sup> A `\value{countname}` is accepted, if there is nothing else, especially before, in the macro argument.

## 10 Output formats

This format with a power of ten represented by a number within square brackets is the output format used by (almost all) **xintfrac** macros dealing with fractions. It is allowed for user input but the parsing is minimal and it is mandatory to follow the above rules. This reduced flexibility, compared to the format without the square brackets, allows chaining package macros without too much speed impact, as they always output computation results in the  $A/B[n]$  form.

All computations done by **xintfrac** on fractions are exact. Inputs containing decimal points or scientific parts do not make the package switch to a ‘floating-point’ mode. The inputs, however long, are always converted into exact internal representations.

Floating point evaluations are done with special macros containing ‘Float’ in their names, or inside `\xintthefloatexpr`-essions.

Generally speaking, there should be no spaces among the digits in the inputs (in arguments to the package macros). Although most would be harmless in most macros, there are some cases where spaces could break havoc. So the best is to avoid them entirely.

This is entirely otherwise inside an `\xintexpr`-ession, where spaces are ignored (except when they occur inside arguments to some some macros, thus escaping the `\xintexpr` parser). See the [documentation](#).

## 10 Output formats

With package **xintfrac** loaded, the routines `\xintAdd`, `\xintSub`, `\xintMul`, `\xintPow`, `\xintSum`, `\xintPrd` are modified to allow fractions on input,<sup>22 23 24 25</sup> and produce on output a fractional number  $f=A/B[n]$  where  $A$  and  $B$  are integers, with  $B$  positive, and  $n$  is a “short” integer (*i.e.* less in absolute value than  $2^{\{31\}-9}$ ). This represents  $(A/B)$  times  $10^n$ . The fraction  $f$  may be, and generally is, reducible, and  $A$  and  $B$  may well end up with zeros (*i.e.*  $n$  does not contain all powers of 10). Conversely, this format is accepted on input (and is parsed more quickly than fractions containing decimal points; the input may be a number without denominator).<sup>26</sup>

Thus loading **xintfrac** not only relaxes the format of the inputs; it also modifies the format of the outputs: except when a fraction is filtered on output by `\xintIrr` or `\xintRawWithZeros`, or `\xintPRaw`, or by the truncation or rounding macros, or is given as argument in math mode to `\xintFrac`, the output format is normally of the  $A/B[n]$  form

<sup>22</sup> the power function does not accept a fractional exponent. Or rather, does not expect, and errors will result if one is provided. <sup>23</sup> macros `\xintiAdd`, `\xintiSub`, `\xintiMul`, `\xintiPow`, are the original ones dealing only with integers. They are available as synonyms, also when **xintfrac** is not loaded. With **xintfrac** loaded they accept on input also fractions, if these fractions reduce to integers, and the output format is the original **xint**’s one. The macros `\xintiiAdd`, `\xintiiSub`, `\xintiiMul`, `\xintiiPow`, `\xintiiSum`, `\xintiiPrd` are strictly integer-only: they skip the overhead of parsing their arguments via `\xintNum`. <sup>24</sup> also `\xintCmp`, `\xintSgn`, `\xintGeg`, `\xintOpp`, `\xintAbs`, `\xintMax`, `\xintMin` are extended to fractions; and the last four have the integer-only variants `\xintiOpp`, `\xintiAbs`, `\xintiMax`, `\xintiMin`. <sup>25</sup> and `\xintFac`, `\xintQuo`, `\xintRem`, `\xintDivision`, `\xintFDg`, `\xintLDg`, `\xintOdd`, `\xintMON`, `\xintMMON` all accept a fractional input as long as it reduces to an integer. <sup>26</sup> at each stage of the computations, the sum of  $n$  and the length of  $A$ , or of the absolute value of  $n$  and the length of  $B$ , must be kept less than  $2^{\{31\}-9}$ .

(which stands for  $(A/B) \times 10^n$ ). The A and B may end in zeros (*i.e.*, n does not represent all powers of ten), and will generally have a common factor. The denominator B is always strictly positive.

A macro `\xintFrac` is provided for the typesetting (math-mode only) of such a ‘raw’ output. The command `\xintFrac` is not accepted as input to the package macros, it is for typesetting only (in math mode).

The macro `\xintRaw` prints the fraction directly from its internal representation in  $A/B[n]$  form. The macro `\xintPRaw` does the same but without printing the  $[n]$  if  $n=0$  and without printing  $/1$  if  $B=1$ .

To convert the trailing  $[n]$  into explicit zeros either at the numerator or the denominator, use `\xintRawWithZeros`. In both cases the B is printed even if it has value 1. Conversely (sort of), the macro `\xintREZ` puts all powers of ten into the  $[n]$  (REZ stands for remove zeros). Here also, the B is printed even if it has value 1.

The macro `\xintIrr` reduces the fraction to its irreducible form  $C/D$  (without a trailing  $[0]$ ), and it prints the D even if  $D=1$ .

The macro `\xintNum` from package `xint` is extended: it now does like `\xintIrr`, raises an error if the fraction did not reduce to an integer, and outputs the numerator. This macro should be used when one knows that necessarily the result of a computation is an integer, and one wants to get rid of its denominator  $/1$  which would be left by `\xintIrr` (or one can use `\xintPRaw` on top of `\xintIrr`).

The macro `\xintTrunc{N}{f}` prints<sup>27</sup> the decimal expansion of  $f$  with  $N$  digits after the decimal point.<sup>28</sup> Currently, it does not verify that  $N$  is non-negative and strange things could happen with a negative  $N$ . A negative  $f$  is no problem, needless to say. When the original fraction is negative and its truncation has only zeros, it is printed as  $-0.0\dots 0$ , with  $N$  zeros following the decimal point:

```
\xintTrunc {5}{\xintPow {-13}{-9}}=-0.00000
```

```
\xintTrunc {20}{\xintPow {-13}{-9}}=-0.00000000009429959537
```

The output always contains a decimal point (even for  $N=0$ ) followed by  $N$  digits, except when the original fraction was zero. In that case the output is  $0$ , with no decimal point.

```
\xintTrunc {10}{\xintSum {{1/2}{1/3}{1/5}{-31/30}}} = 0
```

The macro `\xintiTrunc{N}{f}` is like `\xintTrunc{N}{f}` followed by multiplication by  $10^N$ . Thus, it outputs an integer in a format acceptable by the integer-only macros. To get the integer part of the decimal expansion of  $f$ , use `\xintiTrunc{0}{f}`:

```
\xintiTrunc {0}{\xintPow {1.01}{100}} = 2
```

```
\xintiTrunc {0}{\xintPow {0.123}{-10}} = 1261679032
```

See also the documentations of `\xintRound`, `\xintiRound` and `\xintFloat`.

The `\xintiAdd`, `\xintiSub`, `\xintiMul`, `\xintiPow`, and some others accept fractions on input under the condition that they are (big) integers in disguise and then output a (possibly big) integer, without fraction slash nor trailing  $[n]$ .

The `\xintiiAdd`, `\xintiiSub`, `\xintiiMul`, `\xintiiPow`, and some others with ‘ii’ in

<sup>27</sup> ‘prints’ does not at all mean that this macro is designed for typesetting; I am just using the verb here in analogy to the effect of the functioning of a computing software in console mode. The package does not provide any ‘printing’ facility, besides its rudimentary `\xintFrac` and `\xintFwOver` math-mode only macros. To deal with really long numbers, some macros are necessary as  $\TeX$  by default will print a long number on a single line extending beyond the page limits. The `\printnumber` command used in this documentation is just one way to address this problem, some other method should be used if it is important that digits occupy the same width always. <sup>28</sup> the current release does not provide a macro to get the period of the decimal expansion.

their names accept on input only integers in strict format (skipping the overhead of the `\xintNum` parsing) and output naturally a (possibly big) integer, without fraction slash nor trailing [n].

## 11 Multiple outputs

Some macros have an output consisting of more than one number or fraction, each one is then returned within braces. Examples of multiple-output macros are `\xintDivision` which gives first the quotient and then the remainder of euclidean division, `\xintBezout` from the `xintgcd` package which outputs five numbers, `\xintFtoCv` from the `xintcfrac` package which returns the list of the convergents of a fraction, ... [section 15](#) and [section 16](#) mention utilities, expandable or not, to cope with such outputs.

Another type of multiple outputs is when using commas inside `\xintexpr... \relax`:

```
\xinttheiexpr 10!, 2^20, lcm(1000, 725) \relax → 3628800, 1048576, 29000
```

## 12 Use of count registers

Inside `\xintexpr... \relax` and its variants, a count register or count control sequence is automatically unpacked using `\number`, with tacit multiplication: `1.23\counta` is like `1.23*\counta`. We use `\number` which is slightly slower on count registers than `\the`, because the parser does not discriminate between a count and a dimen control sequence. And `\the` on a dimen variable produces only an approximate representation in points of the internal value in sp units. See the next section for more.

Regarding now the package macros, there is first the case of an argument said in the documentation to have to obey the  $\text{\TeX}$  bound: this means that it is fed to a `\numexpr... \relax`, hence it is submitted to a *complete expansion* which must deliver an integer, and count registers and even algebraic expressions with them like `\mycountA+\mycountB*17-\mycountC/12+\mycountD` are admissible arguments (the slash stands here for the rounded integer division done by `\numexpr`). This applies in particular to the number of digits to truncate or round with, to the indices of a series partial sum, ...

The macros dealing with long numbers or fractions allow (when not limited to the ‘strict integer’ format on input) *to some extent* the direct use of count registers and even infix algebra with them inside their arguments: a count register `\mycountA` or `\count 255` is admissible as numerator or also as denominator, with no need to be prefixed by `\the` or `\number`. It is possible to have as argument an algebraic expression as would be acceptable by a `\numexpr... \relax`, under this condition: *each of the numerator and denominator is expressed with at most eight tokens*.<sup>29</sup> The slash for rounded division in a `\numexpr` should be written with braces `{/}` to not be confused with the `xintfrac` delimiter between numerator and denominator (braces will be removed internally). Example: `\mycountA+\mycountB{/}17/1+\mycountA*\mycountB`, or `\count 0+\count 2{/}17/1+\count 0*\count 2`, but in the latter case the numerator has the maximal allowed number of tokens (the braced slash counts for only one).

**IMPORTANT!** {<sup>29</sup> Attention! there is no problem with a  $\text{\LaTeX}$  `\value{counternam}` if it comes first, but if it comes later in the input it will not get expanded, and braces around the name will be removed and chaos will ensue inside a `\numexpr`. One should enclose the whole input in `\the\numexpr... \relax` in such cases.

## 13 Dimensions

`\cnta 10 \cntb 35 \xintRaw {\cnta+\cntb{/}17/1+\cnta*\cntb}->12/351[0]`  
 For longer algebraic expressions using count registers, there are two possibilities:

1. encompass each of the numerator and denominator in `\the\numexpr...\relax`,
2. encompass each of the numerator and denominator in `\numexpr {...}\relax`.

```
\cnta 100 \cntb 10 \cntc 1
\xintPRaw {\numexpr {\cnta*\cnta+\cntb*\cntb+\cntc*\cntc+
2*\cnta*\cntb+2*\cnta*\cntc+2*\cntb*\cntc}\relax/%
\numexpr {\cnta*\cnta+\cntb*\cntb+\cntc*\cntc}\relax }
12321/10101
```

The braces would not be accepted as regular `\numexpr`-syntax: and indeed, they are removed at some point in the processing.

## 13 Dimensions

*<dimen>* variables can be converted into (short) integers suitable for the **xint** macros by prefixing them with `\number`. This transforms a dimension into an explicit short integer which is its value in terms of the sp unit (1/65536 pt). When `\number` is applied to a *<glue>* variable, the stretch and shrink components are lost.

For L<sup>A</sup>T<sub>E</sub>X users: a length is a *<glue>* variable, prefixing a length command defined by `\newlength` with `\number` will thus discard the plus and minus glue components and return the dimension component as described above, and usable in the **xint** bundle macros.

This conversion is done automatically inside an `\xintexpr`-essions, with tacit multiplication implied if prefixed by some (integral or decimal) number.

One may thus compute areas or volumes with no limitations, in units of sp<sup>2</sup> respectively sp<sup>3</sup>, do arithmetic with them, compare them, etc..., and possibly express some final result back in another unit, with the suitable conversion factor and a rounding to a given number of decimal places.

A [table of dimensions](#) illustrates that the internal values used by T<sub>E</sub>X do not correspond always to the closest rounding. For example a millimeter exact value in terms of sp units is 72.27/10/2.54\*65536=186467.981... and T<sub>E</sub>X uses internally 186467sp (it thus appears that T<sub>E</sub>X truncates to get an integral multiple of the sp unit).

There is something quite amusing with the Didot point. According to the T<sub>E</sub>XBook, 1157 dd=1238 pt. The actual internal value of 1 dd in T<sub>E</sub>X is 70124 sp. We can use **xintcfrac** to display the list of centered convergents of the fraction 70124/65536:

```
\xintListWithSep{, }{\xintFtoCCv{70124/65536}}
1/1, 15/14, 61/57, 107/100, 1452/1357, 17531/16384, and we don't find 1238/1157
therein, but another approximant 1452/1357!
```

And indeed multiplying 70124/65536 by 1157, and respectively 1357, we find the approximations (wait for more, later):

```
"1157 dd"=1237.998474121093...pt
"1357 dd"=1451.999938964843...pt
```

and we seemingly discover that 1357 dd=1452 pt is *far more accurate* than the T<sub>E</sub>XBook formula 1157 dd=1238 pt ! The formula to compute N dd was

```
\xinttheexpr trunc(N\dimexpr 1dd\relax/\dimexpr 1pt\relax,12)\relax}
```

### 13 Dimensions

Unit	definition	Exact value in sp units	T <sub>E</sub> X's value in sp units	Relative error
<b>cm</b>	0.01 m	236814336/127 = 1864679.811...	1864679	-0.0000%
<b>mm</b>	0.001 m	118407168/635 = 186467.981...	186467	-0.0005%
<b>in</b>	2.54 cm	118407168/25 = 4736286.720...	4736286	-0.0000%
<b>pc</b>	12 pt	786432/1 = 786432.000...	786432	0%
<b>pt</b>	1/72.27 in	65536/1 = 65536.000...	65536	0%
<b>bp</b>	1/72 in	1644544/25 = 65781.760...	65781	-0.0012%
3bp	1/24 in	4933632/25 = 197345.280...	197345	-0.0001%
12bp	1/2 in	19734528/25 = 789381.120...	789381	-0.0000%
72bp	3 in	118407168/25 = 4736286.720...	4736286	-0.0000%
<b>dd</b>	1238/1157 pt	81133568/1157 = 70124.086...	70124	-0.0001%
11dd	11*1238/1157 pt	892469248/1157 = 771364.950...	771364	-0.0001%
12dd	12*1238/1157 pt	973602816/1157 = 841489.037...	841489	-0.0000%
<b>sp</b>	1/65536 pt	1/1 = 1.000...	1	0%

**T<sub>E</sub>X dimensions**

What's the catch? The catch is that T<sub>E</sub>X *does not* compute 1157 dd like we just did:

```
1157 dd=\number\dimexpr 1157dd\relax/65536=1238.000000000000...pt
```

```
1357 dd=\number\dimexpr 1357dd\relax/65536=1452.001724243164...pt
```

We thus discover that T<sub>E</sub>X (or rather here, e-T<sub>E</sub>X, but one can check that this works the same in T<sub>E</sub>X82), uses indeed 1238/1157 as a conversion factor, and necessarily intermediate computations are done with more precision than is possible with only integers less than 2<sup>31</sup> (or 2<sup>30</sup> for dimensions). Hence the 1452/1357 ratio is irrelevant, a misleading artefact of the necessary rounding (or, as we see, truncating) for one bp as an integral number of sp's.

Let us now use \xintexpr to compute the value of the Didot point in millimeters, if the above rule is exactly verified:

```
\xinttheexpr trunc(1238/1157*25.4/72.27,12)\relax=0.376065027442...mm
```

This fits very well with the possible values of the Didot point as listed in the [Wikipedia Article](#). The value 0.376065 mm is said to be the *the traditional value in European printers' offices*. So the 1157 dd=1238 pt rule refers to this Didot point, or more precisely to the *conversion factor* to be used between this Didot and T<sub>E</sub>X points.

The actual value in millimeters of exactly one Didot point as implemented in T<sub>E</sub>X is

```
\xinttheexpr trunc(\dimexpr 1dd\relax/65536/72.27*25.4,12)\relax
=0.376064563929...mm
```

The difference of circa 5Å is arguably tiny!

By the way the *European printers' offices* (dixit Wikipedia) *Didot* is thus exactly

```
\xinttheexpr reduce(.376065/(25.4/72.27))\relax=543564351/508000000 pt
```

and the centered convergents of this fraction are 1/1, 15/14, 61/57, 107/100, 1238/1157, 11249/10513, 23736/22183, 296081/276709, 615898/575601, 11382245/10637527, 22148592/20699453, 188570981/176233151, 543564351/508000000. We do recover the 1238/1157 therein!

## 14 `\ifcase`, `\ifnum`, ... constructs

When using things such as `\ifcase \xintSgn{A}` one has to make sure to leave a space after the closing brace for  $\TeX$  to stop its scanning for a number: once  $\TeX$  has finished expanding `\xintSgn{A}` and has so far obtained either 1, 0, or -1, a space (or something ‘unexpandable’) must stop it looking for more digits. Using `\ifcase\xintSgnA` without the braces is very dangerous, because the blanks (including the end of line) following `A` will be skipped and not serve to stop the number which `\ifcase` is looking for. With `\def A{1}`:

```
\ifcase \xintSgnA      0\or OK\else ERROR\fi    ---> gives ERROR
\ifcase \xintSgnA\space 0\or OK\else ERROR\fi    ---> gives OK
\ifcase \xintSgn{A}    0\or OK\else ERROR\fi    ---> gives OK
```

In order to use successfully `\if...\fi` constructions either as arguments to the **xint** bundle expandable macros, or when building up a completely expandable macro of one’s own, one needs some  $\TeX$  nical expertise (see also [item 2](#) on page 13).

It is thus much to be recommended to opt rather for already existing expandable branching macros, such as the ones which are provided by **xint**: `\xintSgnFork`, `\xintifSgn`, `\xintifZero`, `\xintifOne`, `\xintifNotZero`, `\xintifTrueAelseB`, `\xintifCmp`, `\xint-ifGt`, `\xintifLt`, `\xintifEq`, `\xintifOdd`, and `\xintifInt`. See their respective documentations. All these conditionals always have either two or three branches, and empty brace pairs `{}` for unused branches should not be forgotten.

If these tests are to be applied to standard  $\TeX$  short integers, it is more efficient to use (under  $\LaTeX$ ) the equivalent conditional tests from the [etoolbox](#)<sup>30</sup> package.

## 15 Assignments

It might not be necessary to maintain at all times complete expandability. For example why not allow oneself the two definitions `\edefA {\xintQuo{100}{3}}` and `\edefB {\xintRem {100}{3}}`. A special syntax is provided to make these things more efficient, as the package provides `\xintDivision` which computes both quotient and remainder at the same time:

```
\xintAssign\xintDivision{100}{3}\toA\B
\xintAssign\xintDivision{\xintiPow {2}{1000}}{\xintFac{100}}\toA\B
gives \meaningA: macro:->11481324964150750548227839387255106625980551
77841861728836634780658265418947047379704195357988766304843582650600
61503749531707793118627774829601 and \meaningB: macro:->5493629452133
98322513812878622391280734105004984760505953218996123132766490228838
81328787024445820751296031520410548049646250831385676526243868372056
68069376.
```

Another example (which uses a macro from the **xintgcd** package):

```
\xintAssign\xintBezout{357}{323}\toA\B\U\VD
is equivalent to setting A to 357, B to 323, U to -9, V to -10, and D to 17. And indeed
(-9)×357-(-10)×323=17 is a Bezout Identity.
```

Thus, what `\xintAssign` does is to first apply an *f-expansion* to what comes next; it then defines one after the other (using `\def`; an optional argument allows to modify the

<sup>30</sup> <http://www.ctan.org/pkg/etoolbox>

expansion type, see [subsection 27.24](#) for details), the macros found after `\to` to correspond to the successive braced contents (or single tokens) located prior to `\to`.

`\xintAssign\xintBezout{3570902836026}{200467139463}\to\A\B\U\V\D`  
gives then `\U: macro:->5812117166`, `\V: macro:->103530711951` and `\D=3`.

In situations when one does not know in advance the number of items, one has `\xintAssignArray` or its synonym `\xintDigitsOf`:

`\xintDigitsOf\xintiPow{2}{100}\to\DIGITS`

This defines `\DIGITS` to be macro with one parameter, `\DIGITS{0}` gives the size  $N$  of the array and `\DIGITS{n}`, for  $n$  from 1 to  $N$  then gives the  $n$ th element of the array, here the  $n$ th digit of  $2^{100}$ , from the most significant to the least significant. As usual, the generated macro `\DIGITS` is completely expandable (in two steps). As it wouldn't make much sense to allow indices exceeding the  $\text{\TeX}$  bounds, the macros created by `\xintAssignArray` put their argument inside a `\numexpr`, so it is completely expanded and may be a count register, not necessarily prefixed by `\the` or `\number`. Consider the following code snippet:

```
\newcount\cnta
\newcount\cntb
\begingroup
\xintDigitsOf\xintiPow{2}{100}\to\DIGITS
\cnta = 1
\cntb = 0
\loop
\advance \cntb \xintiSqr{\DIGITS{\cnta}}
\ifnum \cnta < \DIGITS{0}
\advance\cnta 1
\repeat
```

`|2^{100}|` (`=\xintiPow {2}{100}`) has `\DIGITS{0}` digits and the sum of their squares is `\the\cntb`. These digits are, from the least to the most significant: `\cnta = \DIGITS{0}`  
`\loop \DIGITS{\cnta}\ifnum \cnta > 1 \advance\cnta -1 , \repeat.`  
`\endgroup`

$2^{100}$  (`=1267650600228229401496703205376`) has 31 digits and the sum of their squares is 679. These digits are, from the least to the most significant: 6, 7, 3, 5, 0, 2, 3, 0, 7, 6, 9, 4, 1, 0, 4, 9, 2, 2, 8, 2, 2, 0, 0, 6, 0, 5, 6, 7, 6, 2, 1.

Warning: `\xintAssign`, `\xintAssignArray` and `\xintDigitsOf` do not do any check on whether the macros they define are already defined.

In the example above, we deliberately broke all rules of complete expandability, but had we wanted to compute the sum of the digits, not the sum of the squares, we could just have written: `\xintiiSum{\xintiPow{2}{100}}=115`. Indeed, `\xintiiSum` is usually used on braced items as in

`\xintiiSum{{123}{-345}{\xintFac{7}}{\xintiOpp{\xintRem{3347}{591}}}}=4426`  
but in the previous example each digit of  $2^{100}$  was treated as one item due to the rules of  $\text{\TeX}$  for parsing macro arguments.

Note: `{-\xintRem{3347}{591}}` would not be a valid input, because the expansion will apply only to the minus sign and leave unaffected the `\xintRem`. So we used `\xintiOpp` which replaces a number with its opposite.

## 16 Utilities for expandable manipulations

The package now has more utilities to deal expandably with ‘lists of things’, which were treated un-expandably in the previous section with `\xintAssign` and `\xintAssignArray`: `\xintReverseOrder` and `\xintLength` since the first release, `\xintApply` and `\xintListWithSep` since 1.04, `\xintRevWithBraces`, `\xintCSVtoList`, `\xintNthElt` since 1.06, `\xintApplyUnbraced`, since 1.06b, `\xintloop` and `\xintiloop` since 1.09g.<sup>31</sup>

As an example the following code uses only expandable operations:

```
|2^{100}| (= \xintiPow {2}{100}) has \xintLen{\xintiPow {2}{100}} digits
and the sum of their squares is
```

```
\xintiiSum{\xintApply {\xintISqr}{\xintiPow {2}{100}}}.
```

These digits are, from the least to the most significant:

```
\xintListWithSep {, }{\xintRev{\xintiPow {2}{100}}}. The thirteenth most
significant digit is \xintNthElt{13}{\xintiPow {2}{100}}. The seventh
least significant one is \xintNthElt{7}{\xintRev{\xintiPow {2}{100}}}.
```

$2^{100}$  (=1267650600228229401496703205376) has 31 digits and the sum of their squares is 679. These digits are, from the least to the most significant: 6, 7, 3, 5, 0, 2, 3, 0, 7, 6, 9, 4, 1, 0, 4, 9, 2, 2, 8, 2, 2, 0, 0, 6, 0, 5, 6, 7, 6, 2, 1. The thirteenth most significant digit is 8. The seventh least significant one is 3.

It would be nicer to do `\edef\z{\xintiPow {2}{100}}`, and then use `\z` in place of `\xintiPow {2}{100}` everywhere as this would spare the CPU some repetitions.

Expandably computing primes is done in [subsection 27.10](#).

## 17 A new kind of for loop

As part of the [utilities](#) coming with the [xinttools](#) package, there is a new kind of for loop, `\xintFor`. Check it out ([subsection 27.17](#)).

## 18 A new kind of expandable loop

Also included in [xinttools](#), `\xintiloop` is an expandable loop giving access to an iteration index, without using count registers which would break expandability. Check it out ([subsection 27.13](#)).

## 19 Exceptions (error messages)

In situations such as division by zero, the package will insert in the  $\TeX$  processing an undefined control sequence (we copy this method from the `bigintcalc` package). This will trigger the writing to the log of a message signaling an undefined control sequence. The name of the control sequence is the message. The error is raised *before* the end of the expansion so as to not disturb further processing of the token stream, after completion of the operation. Generally the problematic operation will output a zero. Possible such error message control sequences:

```
\xintError:ArrayIndexIsNegative
```

<sup>31</sup> All these utilities, as well as `\xintAssign`, `\xintAssignArray` and the `\xintFor` loops are now available from the [xinttools](#) package, independently of the big integers facilities of [xint](#).

```

\xintError:ArrayIndexBeyondLimit
\xintError:FactorialOfNegativeNumber
\xintError:FactorialOfTooBigNumber
\xintError:DivisionByZero
\xintError:NaN
\xintError:FractionRoundedToZero
\xintError:NotAnInteger
\xintError:ExponentTooBig
\xintError:TooBigDecimalShift
\xintError:TooBigDecimalsSplit
\xintError:RootOfNegative
\xintError:NoBezoutForZeros
\xintError:ignored
\xintError:removed
\xintError:inserted
\xintError:bigtroubleahead
\xintError:unknownfunction

```

## 20 Common input errors when using the package macros

Here is a list of common input errors. Some will cause compilation errors, others are more annoying as they may pass through unsignaled.

- using `-` to prefix some macro: `-\xintiSqr{35}/271`.<sup>32</sup>
- using one pair of braces too many `\xintIrr{\{\xintiPow {3}{13}\}/243}` (the computation goes through with no error signaled, but the result is completely wrong).
- using `[]` and decimal points at the same time `1.5/3.5[2]`, or with a sign in the denominator `3/-5[7]`. The scientific notation has no such restriction, the two inputs `1.5/-3.5e-2` and `-1.5e2/3.5` are equivalent: `\xintRaw{1.5/-3.5e-2}=-15/35[2]`, `\xintRaw{-1.5e2/3.5}=-15/35[2]`.
- specifying numerators and denominators with macros producing fractions when **xintfrac** is loaded: `\edef\x{\xintMul {3}{5}/\xintMul{7}{9}}`. This expands to `15/1[0]/63/1[0]` which is invalid on input. Using this `\x` in a fraction macro will most certainly cause a compilation error, with its usual arcane and undecipherable accompanying message. The fix here would be to use `\xintiMul`. The simpler alternative with package **xintexpr**: `\xinttheexpr 3*5/(7*9)\relax`.
- generally speaking, using in a context expecting an integer (possibly restricted to the  $\text{\TeX}$  bound) a macro or expression which returns a fraction: `\xinttheexpr 4/2\relax` outputs `4/2[0]`, not `2`. Use `\xintNum {\xinttheexpr 4/2\relax}` or `\xinttheiexpr 4/2\relax`.

---

<sup>32</sup> to the contrary, this *is* allowed inside an `\xintexpr`-ession.

## 21 Package namespace

Inner macros of `xinttools`, `xint`, `xintfrac`, `xintexpr`, `xintbinhex`, `xintgcd`, `xintseries`, and `xintcfrac` all begin either with `\XINT_` or with `\xint_`.<sup>33</sup> The package public commands all start with `\xint`. Some other control sequences are used only as delimiters, and left undefined, they may have been defined elsewhere, their meaning doesn't matter and is not touched.

`xinttools` defines `\odef`, `\oodef`, `\fdef`, but only if macros with these names do not already exist (`\xintoodef` etc... are defined anyhow for use in `\xintAssign` and `\xintAssignArray`).

## 22 Loading and usage

Usage with LaTeX: `\usepackage{xinttools}`  
`\usepackage{xint}`           % (loads xinttools)  
`\usepackage{xintfrac}`       % (loads xint)  
`\usepackage{xintexpr}`       % (loads xintfrac)  
  
`\usepackage{xintbinhex}` % (loads xint)  
`\usepackage{xintgcd}`       % (loads xint)  
`\usepackage{xintseries}` % (loads xintfrac)  
`\usepackage{xintcfrac}`   % (loads xintfrac)

Usage with TeX: `\input xinttools.sty\relax`  
`\input xint.sty\relax`       % (loads xinttools)  
`\input xintfrac.sty\relax`   % (loads xint)  
`\input xintexpr.sty\relax`   % (loads xintfrac)  
  
`\input xintbinhex.sty\relax` % (loads xint)  
`\input xintgcd.sty\relax`   % (loads xint)  
`\input xintseries.sty\relax` % (loads xintfrac)  
`\input xintcfrac.sty\relax`   % (loads xintfrac)

We have added, directly copied from packages by HEIKO OBERDIEK, a mechanism of reload and  $\varepsilon$ -TeX detection, especially for Plain TeX. As  $\varepsilon$ -TeX is required, the executable `tex` can not be used, `etex` or `pdftex` (version 1.40 or later) or ..., must be invoked. Each package refuses to be loaded twice and automatically loads the other components on which it has dependencies.

Also initially inspired from the HEIKO OBERDIEK packages we have included a complete catcode protection mechanism. The packages may be loaded in any catcode configuration satisfying these requirements: the percent is of category code comment character, the backslash is of category code escape character, digits have category code other and letters have category code letter. Nothing else is assumed, and the previous configuration is restored after the loading of each one of the packages.

This is for the loading of the packages.

<sup>33</sup> starting with release 1.06b the style files use for macro names a more modern underscore `_` rather than the `@` sign. A handful of private macros starting with `\XINT` do not have the underscore for technical reasons: `\XINTsetupcatcodes`, `\XINTdigits` and macros with names starting with `XINTinFloat` or `XINTinfloat`.

For the input of numbers as macro arguments the minus sign must have its standard category code (“*other*”). Similarly the slash used for fractions must have its standard category code. And the square brackets, if made use of in the input, also must be of category code *other*. The ‘e’ of the scientific notation must be of category code letter.

All of those requirements are relaxed for tokens parsed inside an `\xintexpr`-ession (but arguments to macros which have been inserted in the expression must obey the rules, as it is the macro and not the parser which will get the tokens). In an `\xintexpr`-ession, the ‘e’ may be upcased: ‘E’.

The **xint** packages presuppose that the `\space`, `\empty`, `\m@ne`, `\z@` and `\@ne` control sequences have their meanings as in Plain  $\mathrm{T}_{\mathrm{E}}\mathrm{X}$  or  $\mathrm{L}^{\mathrm{A}}\mathrm{T}_{\mathrm{E}}\mathrm{X}2_{\epsilon}$ .

## 23 Installation

### A. Installation using xint.tds.zip:

-----

obtain xint.tds.zip from CTAN:

`http://www.ctan.org/tex-archive/install/macros/generic/xint.tds.zip`

cd to the download repertory and issue

`unzip xint.tds.zip -d <TEXMF>`

for example: (assuming standard access rights, so sudo needed)

`sudo unzip xint.tds.zip -d /usr/local/texlive/texmf-local`

`sudo mktexlsr`

On Mac OS X, installation into user home folder:

`unzip xint.tds.zip -d ~/Library/texmf`

### B. Installation after file extractions:

-----

obtain xint.dtx, xint.ins and the README from CTAN:

`http://www.ctan.org/tex-archive/macros/generic/xint`

- “tex xint.ins” generates the style files

(pre-existing files in the same repertory will be overwritten).

- without xint.ins: “tex or latex or pdflatex or xelatex xint.dtx” will also generate the style files (and xint.ins).

xint.tex is also extracted, use it for the documentation:

- with latex+dvipdfmx: `latex xint.tex` thrice then `dvipdfmx xint.dvi`  
Ignore dvipdfmx warnings. In case the pdf file has problems with fonts, use then rather pdflatex or xelatex.

- with pdflatex or xelatex: run it directly thrice on xint.dtx, or run it on xint.tex after having edited the suitable toggle therein.

When compiling xint.tex, the documentation is by default produced with the source code included. See instructions in the file for changing this default.

When compiling directly xint.dtx, the documentation is produced

## 24 The `\xintexpr` math parser (I)

without the source code (latex+dvips or pdflatex or xelatex).

Finishing the installation: (on first installation the destination repertories may need to be created)

```
xinttools.sty |
  xint.sty |
  xintfrac.sty |
  xintexpr.sty | --> TDS:tex/generic/xint/
xintbinhex.sty |
  xintgcd.sty |
xintseries.sty |
xintcfrac.sty |

xint.dtx --> TDS:source/generic/xint/
xint.ins --> TDS:source/generic/xint/
xint.tex --> TDS:source/generic/xint/

xint.pdf --> TDS:doc/generic/xint/
  README --> TDS:doc/generic/xint/
```

Depending on the TDS destination and the TeX installation, it may be necessary to refresh the TeX installation filename database (mktexlsr)

## 24 The `\xintexpr` math parser (I)

Here is some random formula, defining a  $\LaTeX$  command with three parameters,

```
\newcommand\formula[3]
{\xinttheexpr round((#1 & (#2 | #3)) * (355/113*#3 - (#1 - #2/2)^2), 8) \relax}
```

Let  $a=\#1$ ,  $b=\#2$ ,  $c=\#3$  be the parameters. The first term is the logical operation  $a$  and ( $b$  or  $c$ ) where a number or fraction has truth value 1 if it is non-zero, and 0 otherwise. So here it means that  $a$  must be non-zero as well as  $b$  or  $c$ , for this first operand to be 1, else the formula returns 0. This multiplies a second term which is algebraic. Finally the result (where all intermediate computations are done *exactly*) is rounded to a value with 8 digits after the decimal mark, and printed.

`\formula {771.3/9.1}{1.51e2}{37.73}` expands to 32.81726043

- as everything gets expanded, the characters `+, -, *, /, ^, !, &, |, ?, :, <, >, =, (, )` and the comma `,`, which are used in the infix syntax, should not be active (for example if they serve as shorthands for some language in the Babel system) at the time of the expressions (if they are in use therein). The command `\xintexprSafeCatcodes` resets these characters to their standard catcodes and `\xintexprRestoreCatcodes` restores the status prevailing at the time of the previous `\xintexprSafeCatcodes`.

- the formula may be input without `\xinttheexpr` through suitable nesting of various package macros. Here one could use:

```
\xintRound {8}{\xintMul {\xintAND {#1}{\xintOR {#2}{#3}}}{\xintSub
{\xintMul {355/113}{#3}}{\xintPow {\xintSub {#1}{\xintDiv {#2}{2}}}{2}}}}
with the inherent difficulty of keeping up with braces and everything...
```

- if such a formula is used thousands of times in a document (for plots?), this could impact some parts of the  $\text{\TeX}$  program memory (for technical reasons explained in [section 30](#)). So, a utility `\xintNewExpr` is provided to do the work of translating an `\xintexpr`-ession with parameters into a chain of macro evaluations.<sup>34</sup>

`\xintNewExpr\formula[3]`

`{ round((#1 & (#2 | #3)) * (355/113*#3 - (#1 - #2/2)^2), 8) }`

one gets a command `\formula` with three parameters and meaning:

```
macro:#1#2#3->\romannumeral -'\xintRound {\xintNum {8}}{\xintMul
{\xintAND {#1}{\xintOR {#2}{#3}}}{\xintSub {\xintMul {\xintDiv
{355}{113}}{#3}}{\xintPow {\xintSub {#1}{\xintDiv {#2}{2}}}{2}}}
```

This does the same thing as the hand-written version from the previous item. The use even thousands of times of such an `\xintNewExpr`-generated `\formula` has no memory impact.

- count registers and `\numexpr`-essions are accepted (LaTeX's counters can be inserted using `\value`) without needing `\the` or `\number` as prefix. Also `\dimen` registers and control sequences, skip registers and control sequences (LaTeX's lengths), `\dimexpr`-essions, `\glueexpr`-essions are automatically unpacked using `\number`, discarding the stretch and shrink components and giving the dimension value in sp units (1/65536th of a  $\text{\TeX}$  point). Furthermore, tacit multiplication is implied, when immediately prefixed by a (decimal) number.

New!

- The tacit multiplication is done also when the parser encounters a sub-`\xintexpr`-ession. (but not in front of an unexpected opening parenthesis).

- like a `\numexpr`, an `\xintexpr` is not directly printable, one uses equivalently `\xintthe` `\xintexpr` or `\xinttheexpr`. One may for example define:

```
\def\x {\xintexpr \a + \b \relax} \def\y {\xintexpr \x * \a \relax}
```

where `\x` could have been set up equivalently as `\def\x {( \a + \b )}` but the earlier method is better than with parentheses, as it allows `\xintthe\x`.

- sometimes one needs an integer, not a fraction or decimal number. The `round` function rounds to the nearest integer (half-integers are rounded towards  $\pm\infty$ ), and `\xintexpr round(...)\relax` has an alternative syntax as `\xintiexpr ... \relax`. There is also `\xinttheiexpr`. The rounding is applied to the final result only.

- `\xintiexpr ... \relax (\xinttheiexpr)` is another variant which deals only with (long) integers and skips the overhead of the fraction internal format. The infix operator `/` does euclidean division.

- there is also `\xintboolexpr ... \relax` and `\xinttheboolexpr ... \relax`. Same as regular expression but the final result is converted to 1 if it is not zero. See also `\xint-ifboolexpr` ([subsection 30.11](#)) and the [discussion](#) of the `bool` and `togl` functions in [section 24](#). Here is an example:

```
\xintNewBoolExpr \AssertionA[3]{ #1 & (#2|#3) }
\xintNewBoolExpr \AssertionB[3]{ #1 | (#2&#3) }
\xintNewBoolExpr \AssertionC[3]{ xor(#1,#2,#3) }
```

<sup>34</sup> As it makes some macro definitions, it is not an expandable command. It does not need protection against active characters as it does it itself.

```

\xintFor #1 in {0,1} \do {%
  \xintFor #2 in {0,1} \do {%
    \xintFor #3 in {0,1} \do {%
      \centerline{#1 AND (#2 OR #3) is \AssertionA {#1}{#2}{#3}\hfil
                  #1 OR (#2 AND #3) is \AssertionB {#1}{#2}{#3}\hfil
                  #1 XOR #2 XOR #3 is \AssertionC {#1}{#2}{#3}}}}

```

0 AND (0 OR 0) is 0	0 OR (0 AND 0) is 0	0 XOR 0 XOR 0 is 0
0 AND (0 OR 1) is 0	0 OR (0 AND 1) is 0	0 XOR 0 XOR 1 is 1
0 AND (1 OR 0) is 0	0 OR (1 AND 0) is 0	0 XOR 1 XOR 0 is 1
0 AND (1 OR 1) is 0	0 OR (1 AND 1) is 1	0 XOR 1 XOR 1 is 0
1 AND (0 OR 0) is 0	1 OR (0 AND 0) is 1	1 XOR 0 XOR 0 is 1
1 AND (0 OR 1) is 1	1 OR (0 AND 1) is 1	1 XOR 0 XOR 1 is 0
1 AND (1 OR 0) is 1	1 OR (1 AND 0) is 1	1 XOR 1 XOR 0 is 0
1 AND (1 OR 1) is 1	1 OR (1 AND 1) is 1	1 XOR 1 XOR 1 is 1

- there is also `\xintfloatexpr` ... `\relax` where the algebra is done in floating point approximation (also for each intermediate result). Use the syntax `\xintDigits:=N`; to set the precision. Default: 16 digits.

```
\xintthefloatexpr 2^1000000\relax: 9.990020930143845e30102
```

The square-root operation can be used in `\xintexpr`, it is computed as a float with the precision set by `\xintDigits` or by the optional second argument:

```
\xinttheexpr sqrt(2,60)\relax:
```

```
141421356237309504880168872420969807856967187537694807317668[-59]
```

Notice the `a/b[n]` notation (usually `/b` even if `b=1` gets printed; this is the exception) which is the default format of the macros of the `xintfrac` package (hence of `\xintexpr`).

To get a float format from the `\xintexpr` one needs something more:

```
\xintFloat[60]{\xinttheexpr sqrt(2,60)\relax}:
```

```
1.41421356237309504880168872420969807856967187537694807317668e0
```

The precision used by `\xintfloatexpr` must be set by `\xintDigits`, it can not be passed as an option to `\xintfloatexpr`.

```
\xintDigits:=48; \xintthefloatexpr 2^1000000\relax:
```

```
9.99002093014384507944032764330033590980429139054e30102
```

Floats are quickly indispensable when using the power function (which can only have an integer exponent), as exact results will easily have hundreds of digits.

## 25 The `\xintexpr` math parser (II)

An expression is built with infix operators (including comparison and boolean operators), parentheses, functions, and the two branching operators `?` and `∴`. The parser expands everything from the left to the right and everything may thus be revealed step by step by expansion of macros. Spaces anywhere are allowed.

Note that  $2^{-10}$  is perfectly accepted input, no need for parentheses, as well as  $2^4 \wedge 8$  (which is evaluated as  $(2^4)^8$ ). The minus sign as prefix has various precedence levels: `\xintexpr -3-4*-5^-7\relax` evaluates as  $(-3)-(4*(-(5^(-7))))$  and  $-3^4*-5^-7$  as  $(-((3^(-4))*(-5)))^-7$ .

The characters used in the syntax should not be active. Use `\xintexprSafeCatcodes`,

`\xintexprRestoreCatcodes` if need be (these commands must be exercised out of expansion only context). Apart from that infix operators may be of catcode letter or other, it does not matter, or even of catcode tabulation, math superscript, or math subscript. This should cause no problem. As an alternative to `\xintexprSafeCatcodes` one may also use `\string` inside the expression.

The  $A/B[N]$  notation is the output format of most `xintfrac` macros,<sup>35</sup> but for user input in an `\xintexpr`. `\relax` such a fraction should be written with the scientific notation  $AeN/B$  (possibly within parentheses) or *braces* must be used:  $\{A/B[N]\}$ . The square brackets are *not parsable* if not enclosed in braces together with the fraction.

Braces are also allowed in their usual rôle for arguments to macros (these arguments are thus not seen by the scanner), or to encapsulate *arbitrary* completely expandable material which will not be parsed but completely expanded and *must* return an integer or fraction possibly with decimal mark or in  $A/B[N]$  notation, but is not allowed to have the *e* or *E*. Braced material is not allowed to expand to some infix operator or parenthesis, it is allowed only in locations where the parser expects to find a number or fraction, possibly with decimal marks, but no *e* nor *E*.

One may use sub-`\xintexpr`-expressions nested within a larger one. It is allowed to alternate `\xintfloatexpr`-essions with `\xintexpr`-essions. Do not use `\xinttheexpr` inside an `\xintexpr`: this gives a number in  $A/B[n]$  format which requires protection by braces. Do not put within braces numbers in scientific notation.

See subsection 30.8 for the speed-optimized variant `\xintiexpr` which deals only with long integers.

Here is, listed from the highest priority to the lowest, the complete list of operators and functions. Functions are at the top level of priority. Next are the postfix operators: `!` for the factorial, `?` and `:` are two-fold way and three-fold way branching constructs. Then the *e* and *E* of the scientific notation, the power, multiplication/division, addition/subtraction, comparison, and logical operators. At the lowest level: commas then parentheses.

The `\relax` at the end of an expression is absolutely *mandatory*.

- Functions are at the same top level of priority. All functions even `?` and `!` (as prefix) require parentheses around their argument (possibly a comma separated list).

`floor, ceil, frac, reduce, sqr, abs, sgn, ?, !, not, bool, togl, round, trunc, float, sqrt, quo, rem, if, ifsgn, all, any, xor, add (=sum), mul (=prd), max, min, gcd, lcm.`

`quo` and `rem` operate only on integers; `gcd` and `lcm` also and require `xintgcd` loaded; `togl` requires the `etoolbox` package.

**functions with one (numeric) argument** (numeric: any expression leading to an integer, decimal number, fraction, or floating number in scientific notation) `floor, ceil, frac, reduce, sqr, abs, sgn, ?, !, not`. The `?(x)` function returns the truth value, 1 if  $x > 0$ , 0 if  $x = 0$ . The `!(x)` is the logical not. The `reduce` function puts the

<sup>35</sup> this format is convenient for nesting macros; when displaying the final result of a computation one has `\xintFrac` in math mode, or `\xintIrr` and also `\xintPraw` for inline text mode.

fraction in irreducible form. The `frac` function is fractional part, same sign as the number:

```
\xinttheexpr frac(-3.57)\relax→-57/1[-2]
\xinttheexpr trunc(frac(-3.57),2)\relax→-0.57
\xintthefloatexpr frac(-3.57)\relax→-5.700000000000000e-1.
```

Like the other functions `!` and `?` *must* use parentheses.

**functions with one (alphabetical) argument** **bool**, **togl**. `bool(name)` returns 1 if the  $\TeX$  conditional `\ifname` would act as `\iftrue` and 0 otherwise. This works with conditionals defined by `\newif` (in  $\TeX$  or  $\LaTeX$ ) or with primitive conditionals such as `\ifmmode`. For example:

```
\xintifboolexpr{25*4-if(bool(mmode),100,75)}{YES}{NO}
```

will return *NO* if executed in math mode (the computation is then  $100 - 100 = 0$ ) and *YES* if not (the **if** conditional is described below; the `\xintifboolexpr` test automatically encapsulates its first argument in an `\xintexpr` and follows the first branch if the result is non-zero (see subsection 30.11)).

The alternative syntax `25*4-\ifmmode100\else75\fi` could have been used here, the usefulness of `bool(name)` lies in the availability in the `\xintexpr` syntax of the logic operators of conjunction `&`, inclusive disjunction `|`, negation `!` (or `not`), of the multi-operands functions `all`, `any`, `xor`, of the two branching operators `if` and `ifsgn` (see also `?` and `:`), which allow arbitrarily complicated combinations of various `bool(name)`.

Similarly `togl(name)` returns 1 if the  $\LaTeX$  package `etoolbox`<sup>36</sup> has been used to define a toggle named `name`, and this toggle is currently set to `true`. Using `togl` in an `\xintexpr... \relax` without having loaded `etoolbox` will result in an error from `\iftoggle` being a non-defined macro. If `etoolbox` is loaded but `togl` is used on a name not recognized by `etoolbox` the error message will be of the type “ERROR: Missing `\endcsname` inserted.”, with further information saying that `\protect` should have not been encountered (this `\protect` comes from the expansion of the non-expandable `etoolbox` error message).

When `bool` or `togl` is encountered by the `\xintexpr` parser, the argument enclosed in a parenthesis pair is expanded as usual from left to right, token by token, until the closing parenthesis is found, but everything is taken literally, no computations are performed. For example `togl(2+3)` will test the value of a toggle declared to `etoolbox` with name `2+3`, and not 5. Spaces are gobbled in this process. It is impossible to use `togl` on such names containing spaces, but `\iftoggle{name with spaces}{1}{0}` will work, naturally, as its expansion will pre-empt the `\xintexpr` scanner.

There isn't in `\xintexpr...` a test function available analogous to the `test{\ifsome-test}` construct from the `etoolbox` package; but any *expandable* `\ifsometest` can be inserted directly in an `\xintexpr`-ession as `\ifsometest10` (or `\ifsometest{1}{0}`), for example `if(\ifsometest{1}{0},YES,NO)` (see the `if` operator below) works.

A straight `\ifsometest{YES}{NO}` would do the same more efficiently, the point of `\ifsometest10` is to allow arbitrary boolean combinations using the (described later) `&` and `|` logic operators: `\ifsometest10 & \ifsomeothertest10 | \ifsomeothertest10`, etc... *YES* or *NO* above stand for material compatible with the `\xintexpr` parser syntax.

See also `\xintifboolexpr`, in this context.

<sup>36</sup> <http://www.ctan.org/pkg/etoolbox>

**functions with one mandatory and a second optional argument** `round`, `trunc`, `float`, `sqrt`. For example `round(2^9/3^5,12)=2.106995884774`. The `sqrt` is available also in `\xintexpr`, not only in `\xintfloatexpr`. The second optional argument is then the required float precision.

**functions with two arguments** `quo`, `rem`. These functions are integer only, they give the quotient and remainder in Euclidean division (more generally one can use the `floor` function; related: the `frac` function).

**the if conditional (twofold way)** `if`(cond,yes,no) checks if cond is true or false and takes the corresponding branch. Any non zero number or fraction is logical true. The zero value is logical false. Both “branches” are evaluated (they are not really branches but just numbers). See also the `?` operator.

**the ifsgn conditional (threefold way)** `ifsgn`(cond,<0,=0,>0) checks the sign of cond and proceeds correspondingly. All three are evaluated. See also the `:` operator.

**functions with an arbitrary number of arguments** `all`, `any`, `xor`, `add` (=sum), `mul` (=prd), `max`, `min`, `gcd`, `lcm`: the last two are integer-only and require the `xintgcd` package. Currently, `and` and `or` are left undefined, and the package uses the vocabulary `all` and `any`. They must have at least one argument.

- The three postfix operators `!`, `?`, `:`.

`!` computes the factorial of an integer. `sqrt(36)!` evaluates to `6!` (=720) and not to the square root of `36!` ( $\approx 6.099,125,566,750,542 \times 10^{20}$ ). This is the exact factorial even when used inside `\xintfloatexpr`.

`?` is used as `(cond)?{yes}{no}`. It evaluates the (numerical) condition (any non-zero value counts as true, zero counts as false). It then acts as a macro with two mandatory arguments within braces (hence this escapes from the parser scope, the braces can not be hidden in a macro), chooses the correct branch *without evaluating the wrong one*. Once the braces are removed, the parser scans and expands the uncovered material so for example

```
\xinttheiexpr (3>2)?{5+6}{7-1}2^3\relax
```

is legal and computes `5+62^3=238333`. Note though that it would be better practice to include here the `2^3` inside the branches. The contents of the branches may be arbitrary as long as once glued to what is next the syntax is respected: `\xintexpr (3>2)?{5+(6}{7-(1}2^3)\relax` also works. Differs thus from the `if` conditional in two ways: the false branch is not at all computed, and the number scanner is still active on exit, more digits may follow.

`:` is used as `(cond):{<0}{=0}{>0}`. `cond` is anything, its sign is evaluated (it is not necessary to use `sgn(cond):{<}{=}{>}`) and depending on the sign the correct branch is un-braced, the two others are swallowed. The un-braced branch will then be parsed as usual. Differs from the `ifsgn` conditional as the two false branches are not evaluated and furthermore the number scanner is still active on exit.

```
\def\x{0.33}\def\y{1/3}
```

```
\xinttheexpr (\x-\y):{sqrt}{0}{1/}(y-\x)\relax=5773502691896258[-17]
```

- The `e` and `E` of the scientific notation. They are treated as infix operators of highest priority. The decimal mark is scanned in a special direct way: in `1.12e3` first `1.12` is

formed then only e is found.  $1e3-1$  is 999.

- The power operator  $\wedge$ . It is left associative: `\xinttheiexpr 2^2^3\relax` evaluates to 64, not 256.
- Multiplication and division  $*$ ,  $/$ . The division is left associative, too: `\xinttheiexpr 100/50/2\relax` evaluates to 1, not 4.
- Addition and subtraction  $+$ ,  $-$ . Again,  $-$  is left associative: `\xinttheiexpr 100-50-2\relax` evaluates to 48, not 52.
- Comparison operators  $<$ ,  $>$ ,  $=$  (currently, no  $<=$ ,  $>=$ , ...!).
- Conjunction (logical and):  $\&$ . (no  $\&\&$ !)
- Inclusive disjunction (logical or):  $|$ . (no  $||$ !)
- The comma  $,$ . With `\xinttheiexpr 2^3,3^4,5^6\relax` one obtains as output 8,81,15625.
- The parentheses.

See [subsection 30.2](#) for count and dimen registers and variables.

## 26 Change log for earlier releases

Release 1.09i ([2013/12/18])

- `\xintiexpr` is a variant of `\xintexpr` which is optimized to deal only with (long) integers,  $/$  does a euclidean quotient.
- `\xintnumexpr`, `\xintthenumexpr`, `\xintNewNumExpr` are renamed, respectively, `\xintiexpr`, `\xinttheiexpr`, `\xintNewIExpr`. The earlier denominations are kept but to be removed at some point.
- it is now possible within `\xintexpr... \relax` and its variants to use count, dimen, and skip registers or variables without explicit `\the/\number`: the parser inserts automatically `\number` and a tacit multiplication is implied when a register or variable immediately follows a number or fraction. Regarding dimensions and `\number`, see the further discussion in [section 13](#).
- new conditional `\xintifOne`; `\xintifTrueFalse` renamed to `\xintifTrueAelseB`; new macros `\xintTFrac` (‘fractional part’, mapped to function `frac` in `\xintexpr`-essions), `\xintFloatE`.
- `\xintAssign` admits an optional argument to specify the expansion type to be used: `[]` (none, default), `[o]` (once), `[oo]` (twice), `[f]` (full), `[e]` (`\edef`),... to define the macros
- related to the previous item, `\xinttools` defines `\odef`, `\oodef`, `\fdef` (if the names have already been assigned, it uses `\xintoodef` etc...). These tools are provided for the case one uses the package macros in a non-expandable context, particularly `\oodef` which expands twice the macro replacement text and is thus a faster alternative to `\edef` taking into account that the `\xint` bundle macros expand already completely in only two steps. This can be significant when repeatedly making `\def`-initions expanding to hundreds of digits.
- some across the board slight efficiency improvement as a result of modifications of various types to “fork” macros and “branching conditionals” which are used internally.
- bug-fix: `\xintAND` and `\xintOR` inserted a space token in some cases and did not expand as promised in two steps (bug dating back to 1.09a I think; this bug was without consequences when using  $\&$  and  $|$  in `\xintexpr`-essions, it affected only the macro form) `:-((`.
- bug-fix: `\xintFtoCCv` still ended fractions with the `[0]`’s which were supposed to have been removed since release 1.09b.

## 26 Change log for earlier releases

Release 1.09h ([2013/11/28]):

- parts of the documentation have been re-written or re-organized, particularly the discussion of expansion issues and of input and output formats.
- the expansion types of macro arguments are documented in the margin of the macro descriptions, with conventions mainly taken over from those in the  $\text{\LaTeX}$ 3 documentation.
- a dependency of `xinttools` on `xint` (inside `\xintSeq`) has been removed.
- `\xintTypesetEuclideanAlgorithm` and `\xintTypesetBezoutAlgorithm` have been slightly modified (regarding indentation).
- macros `\xintiSum` and `\xintiPrd` are renamed to `\xintiiSum` and `\xintiiPrd`.
- a count register used in 1.09g in the `\xintFor` loops for parsing purposes has been removed and replaced by use of a `\numexpr`.
- the few uses of `\loop` have been replaced by `\xintloop`/`\xintilloop`.
- all macros of `xinttools` for which it makes sense are now declared `\long`.

Release 1.09g ([2013/11/22]):

- package `xinttools` is detached from `xint`, to make tools such as `\xintFor`, `\xintApplyUnbraced`, and `\xintilloop` available without the `xint` overhead.
- new expandable nestable loops `\xintloop` and `\xintilloop`.
- bugfix: `\xintFor` and `\xintFor*` do not modify anymore the value of `\count 255`.

Release 1.09f ([2013/11/04]):

- new `\xintZapFirstSpaces`, `\xintZapLastSpaces`, `\xintZapSpaces`, `\xintZapSpacesB`, for expandably stripping away leading and/or ending spaces.
- `\xintCSVtoList` by default uses `\xintZapSpacesB` to strip away spaces around commas (or at the start and end of the comma separated list).
- also the `\xintFor` loop will strip out all spaces around commas and at the start and the end of its list argument; and similarly for `\xintForpair`, `\xintForthree`, `\xintForfour`.
- `\xintFor` *et al.* accept all macro parameters from #1 to #9.
- for reasons of inner coherence some macros previously with one extra ‘i’ in their names (e.g. `\xintiMON`) now have a doubled ‘ii’ (`\xintiiMON`) to indicate that they skip the overhead of parsing their inputs via `\xintNum`. Macros with a *single* ‘i’ such as `\xintiAdd` are those which maintain the non-`xintfrac` output format for big integers, but do parse their inputs via `\xintNum` (since release 1.09a). They too may have doubled-i variants for matters of programming optimization when working only with (big) integers and not fractions or decimal numbers.

Release 1.09e ([2013/10/29]):

- new `\xintintegers`, `\xintdimensions`, `\xintrationals` for infinite `\xintFor` loops, interrupted with `\xintBreakFor` and `\xintBreakForAndDo`.
- new `\xintifForFirst`, `\xintifForLast` for the `\xintFor` and `\xintFor*` loops,
- the `\xintFor` and `\xintFor*` loops are now `\long`, the replacement text and the items may contain explicit `\par`’s.
- bug fix, the `\xintFor` loop (not `\xintFor*`) did not correctly detect an empty list.
- new conditionals `\xintifCmp`, `\xintifInt`, `\xintifOdd`.
- bug fix, `\xintiSqrt {0}` crashed. :-((
- the documentation has been enriched with various additional examples, such as the [the quick sort algorithm illustrated](#) or the computation of prime numbers ([subsection 27.11](#), [subsection 27.14](#), [subsection 27.21](#)).
- the documentation explains with more details various expansion related issues, particularly in relation to conditionals.

Release 1.09d ([2013/10/22]):

## 26 Change log for earlier releases

- `\xintFor*` is modified to gracefully handle a space token (or more than one) located at the very end of its list argument (as in for example `\xintFor* #1 in {{a}{b}{c}<space>} \do {stuff}`; spaces at other locations were already harmless). Furthermore this new version *f*-expands the un-braced list items. After `\def\x{{1}{2}}` and `\def\y{{a}\x {b}{c}\x }`, `\y` will appear to `\xintFor*` exactly as if it had been defined as `\def\y{{a}{1}{2}{b}{c}{1}{2}}`.
- same bug fix in `\xintApplyInline`.

Release 1.09c ([2013/10/09]):

- added `bool` and `togl` to the `\xintexpr` syntax; also added `\xintboolexpr` and `\xintifboolexpr`.
- added `\xintNewNumExpr` (now `\xintNewIExpr` and `\xintNewBoolExpr`,
- `\xintFor` is a new type of loop, whose replacement text inserts the comma separated values or list items via macro parameters, rather than encapsulated in macros; the loops are nestable up to four levels (nine levels since 1.09f) and their replacement texts are allowed to close groups as happens with the tabulation in alignments,
- `\xintForpair`, `\xintForthree`, `\xintForfour` are experimental variants of `\xintFor`,
- `\xintApplyInline` has been enhanced in order to be usable for generating rows (partially or completely) in an alignment,
- new command `\xintSeq` to generate (expandably) arithmetic sequences of (short) integers,
- the factorial `!` and branching `?`, `:`, operators (in `\xintexpr... \relax`) have now less precedence than a function name located just before: `func(x)!` is the factorial of `func(x)`, not `func(x!)`,
- again various improvements and changes in the documentation.

Release 1.09b ([2013/10/03]):

- various improvements in the documentation,
- more economical catcode management and re-loading handling,
- removal of all those `[0]`'s previously forcefully added at the end of fractions by various macros of `\xintfrac`,
- `\xintNthElt` with a negative index returns from the tail of the list,
- new macro `\xintPRaw` to have something like what `\xintFrac` does in math mode; i.e. a `\xintRaw` which does not print the denominator if it is one.

Release 1.09a ([2013/09/24]):

- `\xintexpr... \relax` and `\xintfloatexpr... \relax` admit functions in their syntax, with comma separated values as arguments, among them `reduce`, `sqr`, `sqrt`, `abs`, `sgn`, `floor`, `ceil`, `quo`, `rem`, `round`, `trunc`, `float`, `gcd`, `lcm`, `max`, `min`, `sum`, `prd`, `add`, `mul`, `not`, `all`, `any`, `xor`.
- comparison (`<`, `>`, `=`) and logical (`|`, `&`) operators.
- the command `\xintthe` which converts `\xintexpressions` into printable format (like `\the` with `\numexpr`) is more efficient, for example one can do `\xintthe\x` if `\x` was defined to be an `\xintexpr... \relax`:  

```
\def\x{\xintexpr 3^57\relax}\def\y{\xintexpr \x^(-2)\relax}
\def\z{\xintexpr \y-3^-114\relax} \xintthe\z=0/1[0]
```
- `\xintnumexpr ... \relax` (now renamed `\xintiexpr`) is `\xintexpr round( ... ) \relax`.
- `\xintNewExpr` now works with the standard macro parameter character `#`.
- both regular `\xintexpr`-essions and commands defined by `\xintNewExpr` will work with comma separated lists of expressions,
- new commands `\xintFloor`, `\xintCeil`, `\xintMaxof`, `\xintMinof` (package `\xintfrac`), `\xintGCDof`, `\xintLCM`, `\xintLCMof` (package `\xintgcd`), `\xintiflt`, `\xintifGt`, `\xintifSgn`, `\xintANDof`, ...
- The arithmetic macros from package `\xint` now filter their operands via `\xintNum` which means that they may use directly count registers and `\numexpr`-essions without having to prefix them by `\the`. This is thus similar to the situation holding previously but with `\xintfrac` loaded.

## 27 Commands of the **xinttools** package

- a bug introduced in 1.08b made `\xintCmp` crash when one of its arguments was zero. :-((

Release 1.08b ([2013/06/14]):

- Correction of a problem with spaces inside `\xintexpr`-essions.
- Additional improvements to the handling of floating point numbers.
- The macros of **xintfrac** allow to use count registers in their arguments in ways which were not previously documented. See [Use of count registers](#).

Release 1.08a ([2013/06/11]):

- Improved efficiency of the basic conversion from exact fractions to floating point numbers, with ensuing speed gains especially for the power function macros `\xintFloatPow` and `\xintFloatPower`,
- Better management by the **xintfrac** macros `\xintCmp`, `\xintMax`, `\xintMin` and `\xintGeq` of inputs having big powers of ten in them.
- Macros for floating point numbers added to the **xintseries** package.

Release 1.08 ([2013/06/07]):

- Extraction of square roots, for floating point numbers (`\xintFloatSqrt`), and also in a version adapted to integers (`\xintiSqrt`).
- New package **xintbinhex** providing [conversion routines](#) to and from binary and hexadecimal bases.

Release 1.07 ([2013/05/25]):

- The **xintfrac** macros accept numbers written in scientific notation, the `\xintFloat` command serves to output its argument with a given number D of significant figures. The value of D is either given as optional argument to `\xintFloat` or set with `\xintDigits := D`; . The default value is 16.
- The **xintexpr** package is a new core constituent (which loads automatically **xintfrac** and **xint**) and implements the expandable expanding parsers  
`\xintexpr . . . \relax`, and its variant `\xintfloatexpr . . . \relax`  
allowing on input formulas using the standard form with infix operators `+`, `-`, `*`, `/`, and `^`, and arbitrary levels of parenthesizing. Within a float expression the operations are executed according to the current value of `\xintDigits`. Within an `\xintexpr`-ession the binary operators are computed exactly.
- The floating point precision D is set (this is a local assignment to a `\mathchar` variable) with `\xintDigits := D`; and queried with `\xinttheDigits`. It may be set to anything up to 32767.<sup>37</sup> The macro incarnations of the binary operations admit an optional argument which will replace pointwise D; this argument may exceed the 32767 bound.
- To write the `\xintexpr` parser I benefited from the commented source of the L<sup>A</sup>T<sub>E</sub>X3 parser; the `\xintexpr` parser has its own features and peculiarities. See [its documentation](#).

Initial release 1.0 was on 2013/03/28.

## 27 Commands of the **xinttools** package

These utilities used to be provided within the **xint** package; since 1.09g they have been moved to an independently usable package **xinttools**, which has none of the **xint** facilities regarding big numbers. Whenever relevant release 1.09h has made the macros `\long` so they accept `\par` tokens on input.

First the completely expandable utilities up to `\xintiloop`, then the non expandable utilities.

This section contains various concrete examples and ends with a [completely expandable implementation of the Quick Sort algorithm](#) together with a graphical illustration of its action.

---

<sup>37</sup> but values higher than 100 or 200 will presumably give too slow evaluations.

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### 27.1 `\xintReverseOrder`

*n* ★ `\xintReverseOrder{⟨list⟩}` does not do any expansion of its argument and just reverses the order of the tokens in the `⟨list⟩`. Braces are removed once and the enclosed material, now unbraced, does not get reverted. Unprotected spaces (of any character code) are gobbled.

```
\xintReverseOrder{\xintDigitsOf\xintiPow {2}{100}\to\Stuff}
gives: \Stuff\to1002\xintiPow\xintDigitsOf
```

### 27.2 `\xintRevWithBraces`

*f* ★ `\xintRevWithBraces{⟨list⟩}` first does the *f*-expansion of its argument then it reverses the order of the tokens, or braced material, it encounters, adding a pair of braces to each (thus, maintaining brace pairs already existing). Spaces (in-between external brace pairs) are gobbled. This macro is mainly thought out for use on a `⟨list⟩` of such braced material; with such a list as argument the *f*-expansion will only hit against the first opening brace, hence do nothing, and the braced stuff may thus be macros one does not want to expand.

```
\edef\x{\xintRevWithBraces{12345}}
\meaning\x:macro:->{5}{4}{3}{2}{1}
\edef\y{\xintRevWithBraces\x}
\meaning\y:macro:->{1}{2}{3}{4}{5}
```

The examples above could be defined with `\edef`'s because the braced material did not contain macros. Alternatively:

```

\expandafter\def\expandafter\w\expandafter
{\romannumeral0\xintrevwithbraces{\A}{B}{C}{D}{E}}
\meaning\w:macro:->{\E }{\D }{\C }{\B }{\A }

```

- n* ★ The macro `\xintReverseWithBracesNoExpand` does the same job without the initial expansion of its argument.

### 27.3 `\xintLength`

- n* ★ `\xintLength{<list>}` does not do *any* expansion of its argument and just counts how many tokens there are (possibly none). So to use it to count things in the replacement text of a macro one should do `\expandafter\xintLength\expandafter{\x}`. One may also use it inside macros as `\xintLength{#1}`. Things enclosed in braces count as one. Blanks between tokens are not counted. See `\xintNthElt{0}` for a variant which first *f*-expands its argument.

```

\xintLength {\xintiPow {2}{100}}=3
≠ \xintLen {\xintiPow {2}{100}}=31

```

### 27.4 `\xintZapFirstSpaces`, `\xintZapLastSpaces`, `\xintZapSpaces`, `\xintZapSpacesB`

- n* ★ `\xintZapFirstSpaces{<stuff>}` does not do *any* expansion of its argument, nor brace removal of any sort, nor does it alter `<stuff>` in anyway apart from stripping away all *leading* spaces.

This macro will be mostly of interest to programmers who will know what I will now be talking about. *The essential points, naturally, are the complete expandability and the fact that no brace removal nor any other alteration is done to the input.*

$\TeX$ 's input scanner already converts consecutive blanks into single space tokens, but `\xintZapFirstSpaces` handles successfully also inputs with consecutive multiple space tokens. However, it is assumed that `<stuff>` does not contain (except inside braced sub-material) space tokens of character code distinct from 32.

It expands in two steps, and if the goal is to apply it to the expansion text of `\x` to define `\y`, then one should do: `\expandafter\def\expandafter\y\expandafter {\romannumeral0\expandafter\xintzapfirstspaces\expandafter{\x}}`.

Other use case: inside a macro as `\edef\x{\xintZapFirstSpaces {#1}}` assuming naturally that `#1` is compatible with such an `\edef` once the leading spaces have been stripped.

```

\xintZapFirstSpaces { \a { \X } { \b \Y } }->\a { \X } { \b \Y } +++

```

- n* ★ `\xintZapLastSpaces{<stuff>}` does not do *any* expansion of its argument, nor brace removal of any sort, nor does it alter `<stuff>` in anyway apart from stripping away all *ending* spaces. The same remarks as for `\xintZapFirstSpaces` apply.

```

\xintZapLastSpaces { \a { \X } { \b \Y } }-> \a { \X } { \b \Y } +++

```

- n* ★ `\xintZapSpaces{<stuff>}` does not do *any* expansion of its argument, nor brace removal of any sort, nor does it alter `<stuff>` in anyway apart from stripping away all *leading* and all *ending* spaces. The same remarks as for `\xintZapFirstSpaces` apply.

```

\xintZapSpaces { \a { \X } { \b \Y } }->\a { \X } { \b \Y } +++

```

- n* ★ `\xintZapSpacesB{<stuff>}` does not do *any* expansion of its argument, nor does it alter

$\langle stuff \rangle$  in anyway apart from stripping away all leading and all ending spaces and possibly removing one level of braces if  $\langle stuff \rangle$  had the shape  $\langle spaces \rangle \{ braced \} \langle spaces \rangle$ . The same remarks as for `\xintZapFirstSpaces` apply.

```
\xintZapSpacesB { \a { \X } { \b \Y } }->\a { \X } { \b \Y }+++
\xintZapSpacesB { { \a { \X } { \b \Y } } }-> \a { \X } { \b \Y } +++
```

The spaces here at the start and end of the output come from the braced material, and are not removed (one would need a second application for that; recall though that the **xint** zapping macros do not expand their argument).

## 27.5 `\xintCSVtoList`

*f* ★ `\xintCSVtoList{a,b,c...,z}` returns  $\{a\}\{b\}\{c\}\dots\{z\}$ . A *list* is by convention in this manual simply a succession of tokens, where each braced thing will count as one item (“items” are defined according to the rules of  $\text{\TeX}$  for fetching undelimited parameters of a macro, which are exactly the same rules as for  $\text{\LaTeX}$  and command arguments [they are the same things]). The word ‘list’ in ‘comma separated list of items’ has its usual linguistic meaning, and then an “item” is what is delimited by commas.

So `\xintCSVtoList` takes on input a ‘comma separated list of items’ and converts it into a ‘ $\text{\TeX}$  list of braced items’. The argument to `\xintCSVtoList` may be a macro: it will first be *f-expanded*. Hence the item before the first comma, if it is itself a macro, will be expanded which may or may not be a good thing. A space inserted at the start of the first item serves to stop that expansion (and disappears). The macro `\xintCSVtoListNoExpand` does the same job without the initial expansion of the list argument.

Apart from that no expansion of the items is done and the list items may thus be completely arbitrary (and even contain perilous stuff such as unmatched `\if` and `\fi` tokens).

Contiguous spaces and tab characters, are collapsed by  $\text{\TeX}$  into single spaces. All such spaces around commas<sup>38</sup> are removed, as well as the spaces at the start and the spaces at the end of the list.<sup>39</sup> The items may contain explicit `\par`’s or empty lines (converted by the  $\text{\TeX}$  input parsing into `\par` tokens).

```
\xintCSVtoList { 1 , { 2 , 3 , 4 , 5 } , a , {b,T} U , { c , d } , { {x , y} } }
->{1}{2 , 3 , 4 , 5}{a}{b,T} U}{ c , d }{ {x , y} }
```

One sees on this example how braces protect commas from sub-lists to be perceived as delimiters of the top list. Braces around an entire item are removed, even when surrounded by spaces before and/or after. Braces for sub-parts of an item are not removed.

We observe also that there is a slight difference regarding the brace stripping of an item: if the braces were not surrounded by spaces, also the initial and final (but no other) spaces of the *enclosed* material are removed. This is the only situation where spaces protected by braces are nevertheless removed.

From the rules above: for an empty argument (only spaces, no braces, no comma) the output is `{ }` (a list with one empty item), for “<opt. spaces>{ }<opt. spaces>” the output is `{ }` (again a list with one empty item, the braces were removed), for “{ }” the output is `{ }` (again a list with one empty item, the braces were removed and then the inner

<sup>38</sup> and multiple space tokens are not a problem; but those at the top level (not hidden inside braces) *must* be of character code 32. <sup>39</sup> let us recall that this is all done completely expandably... There is absolutely no alteration of any sort of the item apart from the stripping of initial and final space tokens (of character code 32) and brace removal if and only if the item apart from initial and final spaces (or more generally multiple char 32 space tokens) is braced.

space was removed), for “ { } ” the output is {} (again a list with one empty item, the initial space served only to stop the expansion, so this was like “{ }” as input, the braces were removed and the inner space was stripped), for “ { } ” the output is { } (this time the ending space of the first item meant that after brace removal the inner spaces were kept; recall though that  $\TeX$  collapses on input consecutive blanks into one space token), for “ , ” the output consists of two consecutive empty items {}{} . Recall that on output everything is braced, a {} is an “empty” item. Most of the above is mainly irrelevant for every day use, apart perhaps from the fact to be noted that an empty input does not give an empty output but a one-empty-item list (it is as if an ending comma was always added at the end of the input).

```
\def\y{ \a,\b,\c,\d,\e} \xintCSVtoList\y->\{ \a }{\b }{\c }{\d }{\e }
\def\t {{\if},\ifnum,\ifx,\ifdim,\ifcat,\ifmmode}
\xintCSVtoList\t->\{ \if }{\ifnum }{\ifx }{\ifdim }{\ifcat }{\ifmmode }
```

The results above were automatically displayed using  $\TeX$ 's primitive `\meaning`, which adds a space after each control sequence name. These spaces are not in the actual braced items of the produced lists. The first items `\a` and `\if` were either preceded by a space or braced to prevent expansion. The macro `\xintCSVtoListNoExpand` would have done the same job without the initial expansion of the list argument, hence no need for such protection but if `\y` is defined as `\def\y{\a,\b,\c,\d,\e}` we then must do:

```
\expandafter\xintCSVtoListNoExpand\expandafter {\y}
```

Else, we may have direct use:

```
\xintCSVtoListNoExpand {\if,\ifnum,\ifx,\ifdim,\ifcat,\ifmmode}
->\{ \if }{\ifnum }{\ifx }{\ifdim }{\ifcat }{\ifmmode }
```

Again these spaces are an artefact from the use in the source of the document of `\meaning` (or rather here, `\detokenize`) to display the result of using `\xintCSVtoListNoExpand` (which is done for real in this document source).

For the similar conversion from comma separated list to braced items list, but without removal of spaces around the commas, there is `\xintCSVtoListNonStripped` and `\xintCSVtoListNonStrippedNoExpand`.

## 27.6 `\xintNthElt`

<sup>num</sup><sub>x</sub> *f* ★ `\xintNthElt{x}{<list>}` gets (expandably) the *x*th braced item of the *<list>*. An unbraced item token will be returned as is. The list itself may be a macro which is first *f*-expanded.

```
\xintNthElt {3}{{agh}\u{zzz}\v{Z}} is zzz
\xintNthElt {3}{{agh}\u{zzz}\v{Z}} is {zzz}
\xintNthElt {2}{{agh}\u{zzz}\v{Z}} is \u
```

```
\xintNthElt {37}{\xintFac {100}}=9 is the thirty-seventh digit of 100!.
```

```
\xintNthElt {10}{\xintFtoCv {566827/208524}}=1457/536
```

is the tenth convergent of 566827/208524 (uses **xintcfrac** package).

```
\xintNthElt {7}{\xintCSVtoList {1,2,3,4,5,6,7,8,9}}=7
\xintNthElt {0}{\xintCSVtoList {1,2,3,4,5,6,7,8,9}}=9
\xintNthElt {-3}{\xintCSVtoList {1,2,3,4,5,6,7,8,9}}=7
```

If *x*=0, the macro returns the *length* of the expanded list: this is not equivalent to `\xintLength` which does no pre-expansion. And it is different from `\xintLen` which is to be used only on integers or fractions.

If *x*<0, the macro returns the *x*th element from the end of the list.

$\text{num}$   
 $x$   $n$  ★ `\xintNthElt {-5}{\{\{\{agh\}\}\u{zzz}\v{Z}\}}` is `{agh}`  
The macro `\xintNthEltNoExpand` does the same job but without first expanding the list argument: `\xintNthEltNoExpand {-4}{\u\v\w T\x\y\z}` is `T`.

In cases where  $x$  is larger (in absolute value) than the length of the list then `\xintNthElt` returns nothing.

## 27.7 `\xintListWithSep`

$nf$  ★ `\xintListWithSep{sep}{\langle list \rangle}` inserts the given separator `sep` in-between all items of the given list of braced items: this separator may be a macro (or multiple tokens) but will not be expanded. The second argument also may be itself a macro: it is  $f$ -expanded. Applying `\xintListWithSep` removes the braces from the list items (for example `{1}{2}{3}` turns into `1,2,3` via `\xintListWithSep{,}{\{\{1\}\{2\}\{3\}\}}`). An empty input gives an empty output, a singleton gives a singleton, the separator is used starting with at least two elements. Using an empty separator has the net effect of unbracing the braced items constituting the  $\langle list \rangle$  (in such cases the new list may thus be longer than the original).

`\xintListWithSep{:}{\xintFac {20}}=2:4:3:2:9:0:2:0:0:8:1:7:6:6:4:0:0:0:0`

$nn$  ★ The macro `\xintListWithSepNoExpand` does the same job without the initial expansion.

## 27.8 `\xintApply`

$ff$  ★ `\xintApply{\macro}{\langle list \rangle}` expandably applies the one parameter command `\macro` to each item in the  $\langle list \rangle$  given as second argument and returns a new list with these outputs: each item is given one after the other as parameter to `\macro` which is expanded at that time (as usual, *i.e.* fully for what comes first), the results are braced and output together as a succession of braced items (if `\macro` is defined to start with a space, the space will be gobbled and the `\macro` will not be expanded; it is allowed to have its own arguments, the list items serve as last arguments to `\macro`). Hence `\xintApply{\macro}{\{\{1\}\{2\}\{3\}\}}` returns `{\macro{1}}{\macro{2}}{\macro{3}}` where all instances of `\macro` have been already  $f$ -expanded.

Being expandable, `\xintApply` is useful for example inside alignments where implicit groups make standard loops constructs usually fail. In such situation it is often not wished that the new list elements be braced, see [\xintApplyUnbraced](#). The `\macro` does not have to be expandable: `\xintApply` will try to expand it, the expansion may remain partial.

The  $\langle list \rangle$  may itself be some macro expanding (in the previously described way) to the list of tokens to which the command `\macro` will be applied. For example, if the  $\langle list \rangle$  expands to some positive number, then each digit will be replaced by the result of applying `\macro` on it.

```
\def\macro #1{\the\numexpr 9-#1\relax}
\xintApply\macro{\xintFac {20}}=756709799182335999
```

$fn$  ★ The macro `\xintApplyNoExpand` does the same job without the first initial expansion which gave the  $\langle list \rangle$  of braced tokens to which `\macro` is applied.

## 27.9 `\xintApplyUnbraced`

$ff$  ★ `\xintApplyUnbraced{\macro}{\langle list \rangle}` is like [\xintApply](#). The difference is that after

having expanded its list argument, and applied `\macro` in turn to each item from the list, it reassembles the outputs without enclosing them in braces. The net effect is the same as doing

```
\xintListWithSep {}{\xintApply {\macro}{\list}}
```

This is useful for preparing a macro which will itself define some other macros or make assignments, as the scope will not be limited by brace pairs.

```
\def\macro #1{\expandafter\def\csname myself#1\endcsname {#1}}
\xintApplyUnbraced\macro{\elta}{eltb}{eltc}}
\meaning\myselfelta: macro:->elta
\meaning\myselfeltb: macro:->eltb
\meaning\myselfeltc: macro:->eltc
```

*fn* ★ The macro `\xintApplyUnbracedNoExpand` does the same job without the first initial expansion which gave the `\list` of braced tokens to which `\macro` is applied.

## 27.10 `\xintSeq`

$\left[ \begin{smallmatrix} \text{num} \\ x \end{smallmatrix} \right] \text{ num num } x$  ★ `\xintSeq[d]{x}{y}` generates expandably `{x}{x+d}...` up to and possibly including `{y}` if  $d > 0$  or down to and including `{y}` if  $d < 0$ . Naturally `{y}` is omitted if  $y - x$  is not a multiple of  $d$ . If  $d = 0$  the macro returns `{x}`. If  $y - x$  and  $d$  have opposite signs, the macro returns nothing. If the optional argument  $d$  is omitted it is taken to be the sign of  $y - x$ .

The current implementation is only for (short) integers; possibly, a future variant could allow big integers and fractions, although one already has access to similar functionality using `\xintApply` to get any arithmetic sequence of long integers. Currently thus,  $x$  and  $y$  are expanded inside a `\numexpr` so they may be count registers or a  $\text{\LaTeX}$  `\value{counternum}`, or arithmetic with such things.

```
\xintListWithSep{,\hskip2pt plus 1pt minus 1pt }{\xintSeq {12}{-25}}
12, 11, 10, 9, 8, 7, 6, 5, 4, 3, 2, 1, 0, -1, -2, -3, -4, -5, -6, -7, -8, -9, -10,
-11, -12, -13, -14, -15, -16, -17, -18, -19, -20, -21, -22, -23, -24, -25
\xintiisum{\xintSeq [3]{1}{1000}}=167167
```

**IMPORTANT!** { for reasons of efficiency, this macro, when not given the optional argument  $d$ , works backwards, leaving in the token stream the already constructed integers, from the tail down (or up). But this will provoke a failure of the `tex` run if the number of such items exceeds the input stack limit; on my installation this limit is at 5000.

However, when given the optional argument  $d$  (which may be  $+1$  or  $-1$ ), the macro proceeds differently and does not put stress on the input stack (but is significantly slower for sequences with thousands of integers, especially if they are somewhat big). For example: `\xintSeq [1]{0}{5000}` works and `\xintiisum{\xintSeq [1]{0}{5000}}` returns the correct value 12502500.

The produced integers are with explicit literal digits, so if used in `\ifnum` or other tests they should be properly terminated<sup>40</sup>.

## 27.11 Completely expandable prime test

Let us now construct a completely expandable macro which returns 1 if its given input is prime and 0 if not:

<sup>40</sup> a `\space` will stop the  $\text{\TeX}$  scanning of a number and be gobbled in the process, maintaining expandability if this is required; the `\relax` stops the scanning but is not gobbled and remains afterwards as a token.

```
\def\remainder #1#2{\the\numexpr #1-(#1/#2)*#2\relax }
\def\IsPrime #1%
  {\xintANDof {\xintApply {\remainder {#1}}{\xintSeq {2}}{\xintiSqrt{#1}}}}
```

This uses `\xintiSqrt` and assumes its input is at least 5. Rather than *xint*'s own `\xintRem` we used a quicker `\numexpr` expression as we are dealing with short integers. Also we used `\xintANDof` which will return 1 only if all the items are non-zero. The macro is a bit silly with an even input, ok, let's enhance it to detect an even input:

```
\def\IsPrime #1%
  {\xintifOdd {#1}
    {\xintANDof % odd case
      {\xintApply {\remainder {#1}}
        {\xintSeq [2]{3}{\xintiSqrt{#1}}}%
      }%
    }
    {\xintifEq {#1}{2}{1}{0}}%
  }
```

We used the *xint* provided expandable tests (on big integers or fractions) in order for `\IsPrime` to be *f*-expandable.

Our integers are short, but without `\expandafter`'s with `\@firstoftwo`, or some other related techniques, direct use of `\ifnum... \fi` tests is dangerous. So to make the macro more efficient we are going to use the expandable tests provided by the package *etoolbox*<sup>41</sup>. The macro becomes:

```
\def\IsPrime #1%
  {\ifnumodd {#1}
    {\xintANDof % odd case
      {\xintApply {\remainder {#1}}{\xintSeq [2]{3}{\xintiSqrt{#1}}}}
    {\ifnumequal {#1}{2}{1}{0}}}
```

In the odd case however we have to assume the integer is at least 7, as `\xintSeq` generates an empty list if `#1=3` or `5`, and `\xintANDof` returns 1 when supplied an empty list. Let us ease up a bit `\xintANDof`'s work by letting it work on only 0's and 1's. We could use:

```
\def\IsNotDivisibleBy #1#2%
  {\ifnum\numexpr #1-(#1/#2)*#2=0 \expandafter 0\else \expandafter 1\fi}
```

where the `\expandafter`'s are crucial for this macro to be *f*-expandable and hence work within the applied `\xintANDof`. Anyhow, now that we have loaded *etoolbox*, we might as well use:

```
\newcommand{\IsNotDivisibleBy}[2]{\ifnumequal{#1-(#1/#2)*#2}{0}{0}{1}}
```

Let us enhance our prime macro to work also on the small primes:

```
\newcommand{\IsPrime}[1] % returns 1 if #1 is prime, and 0 if not
```

```
{\ifnumodd {#1}
  {\ifnumless {#1}{8}
    {\ifnumequal{#1}{1}{0}{1}}% 3,5,7 are primes
    {\xintANDof
      {\xintApply
        { \IsNotDivisibleBy {#1}}{\xintSeq [2]{3}{\xintiSqrt{#1}}}%
      }}% END OF THE ODD BRANCH
    {\ifnumequal {#1}{2}{1}{0}}% EVEN BRANCH
  }
}
```

---

<sup>41</sup> <http://ctan.org/pkg/etoolbox>

The input is still assumed positive. There is a deliberate blank before `\IsNotDivisibleBy` to use this feature of `\xintApply`: a space stops the expansion of the applied macro (and disappears). This expansion will be done by `\xintANDof`, which has been designed to skip everything as soon as it finds a false (i.e. zero) input. This way, the efficiency is considerably improved.

We did generate via the `\xintSeq` too many potential divisors though. Later sections give two variants: one with `\xintiloop` (subsection 27.14) which is still expandable and another one (subsection 27.21) which is a close variant of the `\IsPrime` code above but with the `\xintFor` loop, thus breaking expandability. The `\xintiloop` variant does not first evaluate the integer square root, the `\xintFor` variant still does. I did not compare their efficiencies.

Let us construct with this expandable primality test a table of the prime numbers up to 1000. We need to count how many we have in order to know how many tab stops one should add in the last row.<sup>42</sup> There is some subtlety for this last row. Turns out to be better to insert a `\\` only when we know for sure we are starting a new row; this is how we have designed the `\OneCell` macro. And for the last row, there are many ways, we use again `\xintApplyUnbraced` but with a macro which gobbles its argument and replaces it with a tabulation character. The `\xintFor*` macro would be more elegant here.

```
\newcounter{primecount}
\newcounter{cellcount}
\newcommand{\NbOfColumns}{13}
\newcommand{\OneCell}[1]{%
  \ifnumequal{\IsPrime{#1}}{1}
  {\stepcounter{primecount}
   \ifnumequal{value{cellcount}}{\NbOfColumns}
   {\setcounter{cellcount}{1}#1}
   {\&\stepcounter{cellcount}#1}%
  } % was prime
  {}% not a prime, nothing to do
}
\newcommand{\OneTab}[1]{&}
\begin{tabular}{|*{\NbOfColumns}{r}|}
\hline
2 \setcounter{cellcount}{1}\setcounter{primecount}{1}%
  \xintApplyUnbraced \OneCell {\xintSeq [2]{3}{999}}%
  \xintApplyUnbraced \OneTab
    {\xintSeq [1]{1}{\the\numexpr\nbOfColumns-\value{cellcount}\relax}}%
  \\
\hline
\end{tabular}
```

There are `\arabic{primecount}` prime numbers up to 1000.

The table has been put in `float` which appears on the following page. We had to be careful to use in the last row `\xintSeq` with its optional argument `[1]` so as to not generate a decreasing sequence from 1 to 0, but really an empty sequence in case the row turns out to already have all its cells (which doesn't happen here but would with a number of columns dividing 168).

---

<sup>42</sup> although a tabular row may have less tabs than in the preamble, there is a problem with the `|` vertical rule, if one does that.

2	3	5	7	11	13	17	19	23	29	31	37	41
43	47	53	59	61	67	71	73	79	83	89	97	101
103	107	109	113	127	131	137	139	149	151	157	163	167
173	179	181	191	193	197	199	211	223	227	229	233	239
241	251	257	263	269	271	277	281	283	293	307	311	313
317	331	337	347	349	353	359	367	373	379	383	389	397
401	409	419	421	431	433	439	443	449	457	461	463	467
479	487	491	499	503	509	521	523	541	547	557	563	569
571	577	587	593	599	601	607	613	617	619	631	641	643
647	653	659	661	673	677	683	691	701	709	719	727	733
739	743	751	757	761	769	773	787	797	809	811	821	823
827	829	839	853	857	859	863	877	881	883	887	907	911
919	929	937	941	947	953	967	971	977	983	991	997	

There are 168 prime numbers up to 1000.

### 27.12 `\xintloop`, `\xintbreakloop`, `\xintbreakloopanddo`, `\xintloopskiptonext`

☆ `\xintloop<stuff>\if<test>...\repeat` is an expandable loop compatible with nesting. However to break out of the loop one almost always need some un-expandable step. The cousin `\xintilooop` is `\xintloop` with an embedded expandable mechanism allowing to exit from the loop. The iterated commands may contain `\par` tokens or empty lines.

If a sub-loop is to be used all the material from the start of the main loop and up to the end of the entire subloop should be braced; these braces will be removed and do not create a group. The simplest to allow the nesting of one or more sub-loops is to brace everything between `\xintloop` and `\repeat`, being careful not to leave a space between the closing brace and `\repeat`.

As this loop and `\xintilooop` will primarily be of interest to experienced T<sub>E</sub>X macro programmers, my description will assume that the user is knowledgeable enough. Some examples in this document will be perhaps more illustrative than my attempts at explanation of use.

One can abort the loop with `\xintbreakloop`; this should not be used inside the final test, and one should expand the `\fi` from the corresponding test before. One has also `\xintbreakloopanddo` whose first argument will be inserted in the token stream after the loop; one may need a macro such as `\xint_afterfi` to move the whole thing after the `\fi`, as a simple `\expandafter` will not be enough.

One will usually employ some count registers to manage the exit test from the loop; this breaks expandability, see `\xintilooop` for an expandable integer indexed loop. Use in alignments will be complicated by the fact that cells create groups, and also from the fact that any encountered unexpandable material will cause the T<sub>E</sub>X input scanner to insert `\endtemplate` on each encountered `&` or `\cr`; thus `\xintbreakloop` may not work as expected, but the situation can be resolved via `\xint_firstofone{&}` or use of `\TAB` with `\def{TAB{&}}`. It is thus simpler for alignments to use rather than `\xintloop` either the expandable `\xintApplyUnbraced` or the non-expandable but alignment compatible `\xintApplyInline`, `\xintFor` or `\xintFor*`.

As an example, let us suppose we have two macros  $\backslash A\{i\}\{j\}$  and  $\backslash B\{i\}\{j\}$  behaving like (small) integer valued matrix entries, and we want to define a macro  $\backslash C\{i\}\{j\}$  giving the matrix product (i and j may be count registers). We will assume that  $\backslash A[I]$  expands to the number of rows,  $\backslash A[J]$  to the number of columns and want the produced  $\backslash C$  to act in the same manner. The code is very dispendious in use of  $\backslash count$  registers, not optimized in any way, not made very robust (the defined macro can not have the same name as the first two matrices for example), we just wanted to quickly illustrate use of the nesting capabilities of  $\backslash xintloop$ .<sup>43</sup>

```

\newcount\rowmax    \newcount\colmax    \newcount\summax
\newcount\rowindex  \newcount\colindex  \newcount\sumindex
\newcount\tmpcount
\makeatletter
\def\MatrixMultiplication #1#2#3{%
  \rowmax #1[I]\relax
  \colmax #2[J]\relax
  \summax #1[J]\relax
  \rowindex 1
  \xintloop % loop over row index i
  {\colindex 1
    \xintloop % loop over col index k
    {\tmpcount 0
      \sumindex 1
      \xintloop % loop over intermediate index j
      \advance\tmpcount \numexpr #1\rowindex\sumindex*#2\sumindex\colindex\relax
      \ifnum\sumindex<\summax
        \advance\sumindex 1
      \repeat }%
      \expandafter\edef\csname\string#3{\the\rowindex.\the\colindex}\endcsname
      {\the\tmpcount}%
      \ifnum\colindex<\colmax
        \advance\colindex 1
      \repeat }%
      \ifnum\rowindex<\rowmax
        \advance\rowindex 1
      \repeat
      \expandafter\edef\csname\string#3{I}\endcsname{\the\rowmax}%
      \expandafter\edef\csname\string#3{J}\endcsname{\the\colmax}%
      \def #3##1{\ifx[##1\expandafter\Matrix@helper@size
        \else\expandafter\Matrix@helper@entry\fi #3{##1}}%
    }%
  }%
\def\Matrix@helper@size #1#2#3{\csname\string#1{#3}\endcsname }%
\def\Matrix@helper@entry #1#2#3%
  {\csname\string#1{\the\numexpr#2.\the\numexpr#3}\endcsname }%
\def\A #1{\ifx[##1\expandafter\A@size
  \else\expandafter\A@entry\fi {#1}}%
\def\A@size #1#2{\ifx I#23\else4\fi}% 3rows, 4columns
\def\A@entry #1#2{\the\numexpr #1+#2-1\relax}% not pre-computed...
\def\B #1{\ifx[##1\expandafter\B@size

```

<sup>43</sup> for a more sophisticated implementation of matrix multiplication, inclusive of determinants, inverses, and display utilities, with entries big integers or decimal numbers or even fractions see <http://tex.stackexchange.com/a/143035/4686> from November 11, 2013.

```

\else\expandafter\B@entry\fi {#1}}%
\def\B@size #1#2{\ifx I#24\else3\fi}% 4rows, 3columns
\def\B@entry #1#2{\the\numexpr #1-#2\relax}% not pre-computed...
\makeatother
\MatrixMultiplication\A\B\C \MatrixMultiplication\C\C\D % etc...
\[\begin{pmatrix}
  \A11&\A12&\A13&\A14\\
  \A21&\A22&\A23&\A24\\
  \A31&\A32&\A33&\A34
\end{pmatrix}
\times
\begin{pmatrix}
  \B11&\B12&\B13\\
  \B21&\B22&\B23\\
  \B31&\B32&\B33\\
  \B41&\B42&\B43
\end{pmatrix}
=
\begin{pmatrix}
  \C11&\C12&\C13\\
  \C21&\C22&\C23\\
  \C31&\C32&\C33
\end{pmatrix}
\end{pmatrix}^2 = \begin{pmatrix}
  \D11&\D12&\D13\\
  \D21&\D22&\D23\\
  \D31&\D32&\D33
\end{pmatrix}
\end{pmatrix}^4
```

$$\begin{pmatrix} 1 & 2 & 3 & 4 \\ 2 & 3 & 4 & 5 \\ 3 & 4 & 5 & 6 \end{pmatrix} \times \begin{pmatrix} 0 & -1 & -2 \\ 1 & 0 & -1 \\ 2 & 1 & 0 \\ 3 & 2 & 1 \end{pmatrix} = \begin{pmatrix} 20 & 10 & 0 \\ 26 & 12 & -2 \\ 32 & 14 & -4 \end{pmatrix}$$

$$\begin{pmatrix} 20 & 10 & 0 \\ 26 & 12 & -2 \\ 32 & 14 & -4 \end{pmatrix}^2 = \begin{pmatrix} 660 & 320 & -20 \\ 768 & 376 & -16 \\ 876 & 432 & -12 \end{pmatrix}$$

$$\begin{pmatrix} 20 & 10 & 0 \\ 26 & 12 & -2 \\ 32 & 14 & -4 \end{pmatrix}^3 = \begin{pmatrix} 20880 & 10160 & -560 \\ 24624 & 11968 & -688 \\ 28368 & 13776 & -816 \end{pmatrix}$$

$$\begin{pmatrix} 20 & 10 & 0 \\ 26 & 12 & -2 \\ 32 & 14 & -4 \end{pmatrix}^4 = \begin{pmatrix} 663840 & 322880 & -18080 \\ 781632 & 380224 & -21184 \\ 899424 & 437568 & -24288 \end{pmatrix}$$

### 27.13 `\xintilooop`, `\xintilooopindex`, `\xintouterilooopindex`, `\xintbreakilooop`, `\xintbreakilooopanddo`, `\xintilooopskiptonext`, `\xintilooopskipandredo`

☆ `\xintilooop[start+delta]<stuff>\if<test> ... \repeat` is a completely expandable nestable loop. complete expandability depends naturally on the actual iterated contents, and complete expansion will not be achievable under a sole *f*-expansion, as is indicated by the hollow star in the margin; thus the loop can be used inside an `\edef` but not inside arguments to the package macros. It can be used inside an `\xintexpr... \relax`.

This loop benefits via `\xintilooopindex` to (a limited access to) the integer index of the iteration. The starting value `start` (which may be a `\count`) and increment `delta` (*id.*) are mandatory arguments. A space after the closing square bracket is not significant, it will be ignored. Spaces inside the square brackets will also be ignored as the two arguments are first given to a `\numexpr... \relax`. Empty lines and explicit `\par` tokens are accepted.

As with `\xintloop`, this tool will mostly be of interest to advanced users. For nesting, one puts inside braces all the material from the start (immediately after `[start+delta]`) and up to and inclusive of the inner loop, these braces will be removed and do not create a loop. In case of nesting, `\xintouterilooopindex` gives access to the index of the outer

loop. If needed one could write on its model a macro giving access to the index of the outer loop (or even to the *n*th outer loop).

The `\xintloopindex` and `\xintouterloopindex` can not be used inside braces, and generally speaking this means they should be expanded first when given as argument to a macro, and that this macro receives them as delimited arguments, not braced ones. Or, but naturally this will break expandability, one can assign the value of `\xintloopindex` to some `\count`. Both `\xintloopindex` and `\xintouterloopindex` extend to the literal representation of the index, thus in `\ifnum` tests, if it comes last one has to correctly end the macro with a `\space`, or encapsulate it in a `\numexpr... \relax`.

When the repeat-test of the loop is, for example, `\ifnum\xintloopindex<10 \repeat`, this means that the last iteration will be with `\xintloopindex=10` (assuming `delta=1`). There is also `\ifnum\xintloopindex=10 \else\repeat` to get the last iteration to be the one with `\xintloopindex=10`.

One has `\xintbreakloop` and `\xintbreakloopanddo` to abort the loop. The syntax of `\xintbreakloopanddo` is a bit surprising, the sequence of tokens to be executed after breaking the loop is not within braces but is delimited by a dot as in:

```
\xintbreakloopanddo <afterloop>.etc.. etc... \repeat
```

The reason is that one may wish to use the then current value of `\xintloopindex` in `<afterloop>` but it can't be within braces at the time it is evaluated. However, it is not that easy as `\xintloopindex` must be expanded before, so one ends up with code like this:

```
\expandafter\xintbreakloopanddo\expandafter\macro\xintloopindex.%
etc.. etc.. \repeat
```

As moreover the `\fi` from the test leading to the decision of breaking out of the loop must be cleared out of the way, the above should be a branch of an expandable conditional test, else one needs something such as:

```
\xint_afterfi{\expandafter\xintbreakloopanddo\expandafter\macro\xintloopindex.}%
\xint_afterfi{\fi etc..etc.. \repeat
```

There is `\xintloopskiptonext` to abort the current iteration and skip to the next, `\xintloopskipandredo` to skip to the end of the current iteration and redo it with the same value of the index (something else will have to change for this not to become an eternal loop...).

Inside alignments, if the looped-over text contains a `&` or a `\cr`, any un-expandable material before a `\xintloopindex` will make it fail because of `\endtemplate`; in such cases one can always either replace `&` by a macro expanding to it or replace it by a suitable `\firstofone{&}`, and similarly for `\cr`.

As an example, let us construct an `\edef\z{...}` which will define `\z` to be a list of prime numbers:

```
\edef\z
{\xintloop [10001+2]
 {\xintloop [3+2]
  \ifnum\xintouterloopindex<\numexpr\xintloopindex*\xintloopindex\relax
  \xintouterloopindex,
  \expandafter\xintbreakloop
 \fi
 \ifnum\xintouterloopindex=\numexpr
 (\xintouterloopindex/\xintloopindex)*\xintloopindex\relax
 \else
```

```

\repeat
}% no space here
\ifnum \xintloopindex < 10999 \repeat }%
\meaning\z macro:->10007, 10009, 10037, 10039, 10061, 10067, 10069, 10079, 10091,
10093, 10099, 10103, 10111, 10133, 10139, 10141, 10151, 10159, 10163, 10169, 10177,
10181, 10193, 10211, 10223, 10243, 10247, 10253, 10259, 10267, 10271, 10273, 10289,
10301, 10303, 10313, 10321, 10331, 10333, 10337, 10343, 10357, 10369, 10391, 10399,
10427, 10429, 10433, 10453, 10457, 10459, 10463, 10477, 10487, 10499, 10501, 10513,
10529, 10531, 10559, 10567, 10589, 10597, 10601, 10607, 10613, 10627, 10631, 10639,
10651, 10657, 10663, 10667, 10687, 10691, 10709, 10711, 10723, 10729, 10733, 10739,
10753, 10771, 10781, 10789, 10799, 10831, 10837, 10847, 10853, 10859, 10861, 10867,
10883, 10889, 10891, 10903, 10909, 10937, 10939, 10949, 10957, 10973, 10979, 10987,
10993, and we should have taken some steps to not have a trailing comma, but the point
was to show that one can do that in an \edef! See also subsection 27.14 which extracts
from this code its way of testing primality.

```

Let us create an alignment where each row will contain all divisors of its first entry.

```

\tabskiplex
\halign{&\hfil#\hfil\cr
\xintloop [1+1]
{\expandafter\bfseries\xintloopindex &
\xintloop [1+1]
\ifnum\xintouterloopindex=\numexpr
(\xintouterloopindex/\xintloopindex)*\xintloopindex\relax
\xintloopindex&\fi
\ifnum\xintloopindex<\xintouterloopindex\space % \space is CRUCIAL
\repeat \cr }%
\ifnum\xintloopindex<30
\repeat }

```

We wanted this first entry in bold face, but `\bfseries` leads to unexpandable tokens, so the `\expandafter` was necessary for `\xintloopindex` and `\xintouterloopindex` not to be confronted with a hard to digest `\endtemplate`. An alternative way of coding is:

```

\def\firstofone #1{#1}%
\halign{&\hfil#\hfil\cr
\xintloop [1+1]
{\bfseries\xintloopindex\firstofone{&}}%
\xintloop [1+1] \ifnum\xintouterloopindex=\numexpr
(\xintouterloopindex/\xintloopindex)*\xintloopindex\relax
\xintloopindex\firstofone{&}\fi
\ifnum\xintloopindex<\xintouterloopindex\space % \space is CRUCIAL
\repeat \firstofone{\cr}}%
\ifnum\xintloopindex<30 \repeat }

```

Here is the output, thus obtained without any count register:

<b>1</b> 1	<b>7</b> 1 7
<b>2</b> 1 2	<b>8</b> 1 2 4 8
<b>3</b> 1 3	<b>9</b> 1 3 9
<b>4</b> 1 2 4	<b>10</b> 1 2 5 10
<b>5</b> 1 5	<b>11</b> 1 11
<b>6</b> 1 2 3 6	<b>12</b> 1 2 3 4 6 12

<b>13</b> 1 13	<b>22</b> 1 2 11 22
<b>14</b> 1 2 7 14	<b>23</b> 1 23
<b>15</b> 1 3 5 15	<b>24</b> 1 2 3 4 6 8 12 24
<b>16</b> 1 2 4 8 16	<b>25</b> 1 5 25
<b>17</b> 1 17	<b>26</b> 1 2 13 26
<b>18</b> 1 2 3 6 9 18	<b>27</b> 1 3 9 27
<b>19</b> 1 19	<b>28</b> 1 2 4 7 14 28
<b>20</b> 1 2 4 5 10 20	<b>29</b> 1 29
<b>21</b> 1 3 7 21	<b>30</b> 1 2 3 5 6 10 15 30

### 27.14 Another completely expandable prime test

The `\IsPrime` macro from [subsection 27.11](#) checked expandably if a (short) integer was prime, here is a partial rewrite using `\xintilooop`. We use the `etoolbox` expandable conditionals for convenience, but not everywhere as `\xintilooopindex` can not be evaluated while being braced. This is also the reason why `\xintbreakilooopanddo` is delimited, and the next macro `\SmallestFactor` which returns the smallest prime factor exemplifies that. One could write more efficient completely expandable routines, the aim here was only to illustrate use of the general purpose `\xintilooop`. A little table giving the first values of `\SmallestFactor` follows, its coding uses `\xintFor`, which is described later; none of this uses count registers.

```
\newcommand{\IsPrime}[1] % returns 1 if #1 is prime, and 0 if not
{
  {\ifnumodd {#1}
    {\ifnumless {#1}{8}
      {\ifnumequal{#1}{1}{0}{1}}% 3,5,7 are primes
      {\if
        \xintilooop [3+2]
        \ifnum#1<\numexpr\xintilooopindex*\xintilooopindex\relax
          \expandafter\xintbreakilooopanddo\expandafter1\expandafter.%
        \fi
        \ifnum#1=\numexpr (#1/\xintilooopindex)*\xintilooopindex\relax
        \else
        \repeat 00\expandafter0\else\expandafter1\fi
      }%
    }% END OF THE ODD BRANCH
    {\ifnumequal {#1}{2}{1}{0}}% EVEN BRANCH
  }%
}
\catcode'\_ 11
\newcommand{\SmallestFactor}[1] % returns the smallest prime factor of #1>1
{
  {\ifnumodd {#1}
    {\ifnumless {#1}{8}
      {#1}% 3,5,7 are primes
      {\xintilooop [3+2]
        \ifnum#1<\numexpr\xintilooopindex*\xintilooopindex\relax
          \xint_afterfi{\xintbreakilooopanddo#1.}%
        \fi
        \ifnum#1=\numexpr (#1/\xintilooopindex)*\xintilooopindex\relax
          \xint_afterfi{\expandafter\xintbreakilooopanddo\xintilooopindex.}%
        \fi
        \iftrue\repeat
      }
    }
  }
}
```

```

}%
}% END OF THE ODD BRANCH
{2}% EVEN BRANCH
}%
\catcode'\_ 8
\begin{tabular}{|c|*{10}c|}
\hline
\xintFor #1 in {0,1,2,3,4,5,6,7,8,9}\do {\bfseries #1}\\
\hline
\bfseries 0&--&--&2&3&2&5&2&7&2&3\\
\xintFor #1 in {1,2,3,4,5,6,7,8,9}\do
{\bfseries #1%
\xintFor #2 in {0,1,2,3,4,5,6,7,8,9}\do
{\&\SmallestFactor{#1#2}}\\}%
\hline
\end{tabular}

```

	0	1	2	3	4	5	6	7	8	9
0	—	—	2	3	2	5	2	7	2	3
1	2	11	2	13	2	3	2	17	2	19
2	2	3	2	23	2	5	2	3	2	29
3	2	31	2	3	2	5	2	37	2	3
4	2	41	2	43	2	3	2	47	2	7
5	2	3	2	53	2	5	2	3	2	59
6	2	61	2	3	2	5	2	67	2	3
7	2	71	2	73	2	3	2	7	2	79
8	2	3	2	83	2	5	2	3	2	89
9	2	7	2	3	2	5	2	97	2	3

### 27.15 A table of factorizations

As one more example with `\xintloop` let us use an alignment to display the factorization of some numbers. The loop will actually only play a minor rôle here, just handling the row index, the row contents being almost entirely produced via a macro `\factorize`. The factorizing macro does not use `\xintloop` as it didn't appear to be the convenient tool. As `\factorize` will have to be used on `\xintloopindex`, it has been defined as a delimited macro.

To spare some fractions of a second in the compilation time of this document (which has many many other things to do), 2147483629 and 2147483647, which turn out to be prime numbers, are not given to factorize but just typeset directly; this illustrates use of `\xintloopskiptonext`.

```

\tabskiplex
\halign {\hfil\strut#\hfil&\hfil#\hfil\cr\noalign{\hrule}
\xintloop ["7FFFFFFE0+1]
\expandafter\bfseries\xintloopindex &
\ifnum\xintloopindex="7FFFFFFED
\number"7FFFFFFED\cr\noalign{\hrule}
\expandafter\xintloopskiptonext
\fi
\expandafter\factorize\xintloopindex.\cr\noalign{\hrule}

```

```

\ifnum\xintloopindex<"7FFFFFFE
\repeat
\bfseries \number"7FFFFFFF&\number "7FFFFFFF\cr\noalign{\hrule}
}

```

The `table` has been made into a float which appears on the next page. Here is now the code for factorization; the conditionals use the package provided `\xint_firstoftwo` and `\xint_secondoftwo`, one could have employed rather L<sup>A</sup>T<sub>E</sub>X's own `\@firstoftwo` and `\@secondoftwo`, or, simpler still in L<sup>A</sup>T<sub>E</sub>X context, the `\ifnumequal`, `\ifnumless` ..., utilities from the package `etoolbox` which do exactly that under the hood. Only T<sub>E</sub>X acceptable numbers are treated here, but it would be easy to make a translation and use the **xint** macros, thus extending the scope to big numbers; naturally up to a cost in speed.

The reason for some strange looking expressions is to avoid arithmetic overflow.

```

\catcode'\_ 11
\def\abortfactorize #1\xint_secondoftwo\fi #2#3{\fi}

\def\factorize #1.{\ifnum#1=1 \abortfactorize\fi
% avoid overflow if #1="7FFFFFFF
\ifnum\numexpr #1-2=\numexpr ((#1/2)-1)*2\relax
\expandafter\xint_firstoftwo
\else\expandafter\xint_secondoftwo
\fi
{2&\expandafter\factorize\the\numexpr#1/2.}%
{\factorize_b #1.3.}}%

\def\factorize_b #1.#2.{\ifnum#1=1 \abortfactorize\fi
% this will avoid overflow which could result from #2*#2
\ifnum\numexpr #1-(#2-1)*#2<#2
#1\abortfactorize % this #1 is prime
\fi
% again, avoiding overflow as \numexpr integer division
% rounds rather than truncates.
\ifnum \numexpr #1-#2=\numexpr ((#1/#2)-1)*#2\relax
\expandafter\xint_firstoftwo
\else\expandafter\xint_secondoftwo
\fi
{#2&\expandafter\factorize_b\the\numexpr#1/#2.#2.}%
{\expandafter\factorize_b\the\numexpr #1\expandafter.%
\the\numexpr #2+2.}}%

\catcode'\_ 8

```

The next utilities are not compatible with expansion-only context.

## 27.16 `\xintApplyInline`

*o \** `\xintApplyInline{\macro}{\langle list \rangle}` works non expandably. It applies the one-parameter `\macro` to the first element of the expanded list (`\macro` may have itself some arguments, the list item will be appended as last argument), and is then re-inserted in the input stream after the tokens resulting from this first expansion of `\macro`. The next item is then handled.

2147483616	2	2	2	2	2	3	2731	8191
2147483617	6733	318949						
2147483618	2	7	367	417961				
2147483619	3	3	23	353	29389			
2147483620	2	2	5	4603	23327			
2147483621	14741	145681						
2147483622	2	3	17	467	45083			
2147483623	79	967	28111					
2147483624	2	2	2	11	13	1877171		
2147483625	3	5	5	5	7	199	4111	
2147483626	2	19	37	1527371				
2147483627	47	53	862097					
2147483628	2	2	3	3	59652323			
2147483629	2147483629							
2147483630	2	5	6553	32771				
2147483631	3	137	263	19867				
2147483632	2	2	2	2	7	73	262657	
2147483633	5843	367531						
2147483634	2	3	12097	29587				
2147483635	5	11	337	115861				
2147483636	2	2	536870909					
2147483637	3	3	3	13	6118187			
2147483638	2	2969	361651					
2147483639	7	17	18046081					
2147483640	2	2	2	3	5	29	43	113 127
2147483641	2699	795659						
2147483642	2	23	46684427					
2147483643	3	715827881						
2147483644	2	2	233	1103	2089			
2147483645	5	19	22605091					
2147483646	2	3	3	7	11	31	151	331
2147483647	2147483647							

A table of factorizations

This is to be used in situations where one needs to do some repetitive things. It is not expandable and can not be completely expanded inside a macro definition, to prepare material for later execution, contrarily to what `\xintApply` or `\xintApplyUnbraced` achieve.

```
\def\Macro #1{\advance\cnta #1 , \the\cnta}
\cnta 0
```

`0\xintApplyInline\Macro {3141592653}`. Output: 0, 3, 4, 8, 9, 14, 23, 25, 31, 36, 39.

The first argument `\macro` does not have to be an expandable macro.

`\xintApplyInline` submits its second, token list parameter to an *f-expansion*. Then, each *unbraced* item will also be *f-expanded*. This provides an easy way to insert one list inside another. *Braced* items are not expanded. Spaces in-between items are gobbled (as well as those at the start or the end of the list), but not the spaces *inside* the braced items.

`\xintApplyInline`, despite being non-expandable, does survive to contexts where the executed `\macro` closes groups, as happens inside alignments with the tabulation character `&`. This tabular for example:

$N$	$N^2$	$N^3$
17	289	4913
28	784	21952
39	1521	59319
50	2500	125000
61	3721	226981

was obtained from the following input:

```
\begin{tabular}{ccc}
  $N$ & $N^2$ & $N^3$ \\ \hline
  \def\Row #1{ #1 & \xintiSqr {#1} & \xintiPow {#1}{3} \\ \hline }%
  \xintApplyInline \Row {\xintCSVtoList{17,28,39,50,61}}
\end{tabular}
```

Despite the fact that the first encountered tabulation character in the first row close a group and thus erases `\Row` from  $\text{T}_{\text{E}}\text{X}$ 's memory, `\xintApplyInline` knows how to deal with this.

Using `\xintApplyUnbraced` is an alternative: the difference is that this would have prepared all rows first and only put them back into the token stream once they are all assembled, whereas with `\xintApplyInline` each row is constructed and immediately fed back into the token stream: when one does things with numbers having hundreds of digits, one learns that keeping on hold and shuffling around hundreds of tokens has an impact on  $\text{T}_{\text{E}}\text{X}$ 's speed (make this “thousands of tokens” for the impact to be noticeable).

One may nest various `\xintApplyInline`'s. For example (see the [table](#) on this page):

```
\def\Row #1{#1:\xintApplyInline {\Item {#1}}{0123456789}\\ }%
\def\Item #1#2{&\xintiPow {#1}{#2}}%
\begin{tabular}{cccccccccc}
  & 0 & 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 \\ \hline
  0: & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
  1: & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\
  2: & 1 & 2 & 4 & 8 & 16 & 32 & 64 & 128 & 256 & 512 \\
  3: & 1 & 3 & 9 & 27 & 81 & 243 & 729 & 2187 & 6561 & 19683 \\
  4: & 1 & 4 & 16 & 64 & 256 & 1024 & 4096 & 16384 & 65536 & 262144 \\
  5: & 1 & 5 & 25 & 125 & 625 & 3125 & 15625 & 78125 & 390625 & 1953125 \\
  6: & 1 & 6 & 36 & 216 & 1296 & 7776 & 46656 & 279936 & 1679616 & 10077696 \\
  7: & 1 & 7 & 49 & 343 & 2401 & 16807 & 117649 & 823543 & 5764801 & 40353607 \\
  8: & 1 & 8 & 64 & 512 & 4096 & 32768 & 262144 & 2097152 & 16777216 & 134217728 \\
  9: & 1 & 9 & 81 & 729 & 6561 & 59049 & 531441 & 4782969 & 43046721 & 387420489
\end{tabular}
```

	0	1	2	3	4	5	6	7	8	9
0:	1	0	0	0	0	0	0	0	0	0
1:	1	1	1	1	1	1	1	1	1	1
2:	1	2	4	8	16	32	64	128	256	512
3:	1	3	9	27	81	243	729	2187	6561	19683
4:	1	4	16	64	256	1024	4096	16384	65536	262144
5:	1	5	25	125	625	3125	15625	78125	390625	1953125
6:	1	6	36	216	1296	7776	46656	279936	1679616	10077696
7:	1	7	49	343	2401	16807	117649	823543	5764801	40353607
8:	1	8	64	512	4096	32768	262144	2097152	16777216	134217728
9:	1	9	81	729	6561	59049	531441	4782969	43046721	387420489

One could not move the definition of `\Item` inside the tabular, as it would get lost after the first `&`. But this works:

```
\begin{tabular}{cccccccccc}
  & 0 & 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 \\ \hline
```

```

\def\Row #1{#1:\xintApplyInline {\&\xintiPow {#1}}{0123456789}\ }%
\xintApplyInline \Row {0123456789}
\end{tabular}

```

A limitation is that, contrarily to what one may have expected, the `\macro` for an `\xintApplyInline` can not be used to define the `\macro` for a nested sub-`\xintApplyInline`. For example, this does not work:

```

\def\Row #1{#1:\def\Item ##1{\&\xintiPow {#1}{##1}}%
\xintApplyInline \Item {0123456789}\ }%
\xintApplyInline \Row {0123456789} % does not work

```

But see `\xintFor`.

### 27.17 `\xintFor`, `\xintFor*`

*on* `\xintFor` is a new kind of for loop. Rather than using macros for encapsulating list items, its behavior is more like a macro with parameters: #1, #2, ..., #9 are used to represent the items for up to nine levels of nested loops. Here is an example:

```

\xintFor #9 in {1,2,3} \do {%
  \xintFor #1 in {4,5,6} \do {%
    \xintFor #3 in {7,8,9} \do {%
      \xintFor #2 in {10,11,12} \do {%
        $$#9\times#1\times#3\times#2=\xintiiPrd{{#1}{#2}{#3}{#9}}$$$$}}

```

This example illustrates that one does not have to use #1 as the first one: the order is arbitrary. But each level of nesting should have its specific macro parameter. Nine levels of nesting is presumably overkill, but I did not know where it was reasonable to stop. `\par` tokens are accepted in both the comma separated list and the replacement text.

A macro `\macro` whose definition uses internally an `\xintFor` loop may be used inside another `\xintFor` loop even if the two loops both use the same macro parameter. Note: the loop definition inside `\macro` must double the character # as is the general rule in  $\text{\TeX}$  with definitions done inside macros.

The macros `\xintFor` and `\xintFor*` are not expandable, one can not use them inside an `\edef`. But they may be used inside alignments (such as a  $\text{\LaTeX}$  `tabular`), as will be shown in examples.

The spaces between the various declarative elements are all optional; furthermore spaces around the commas or at the start and end of the list argument are allowed, they will be removed. If an item must contain itself commas, it should be braced to prevent these commas from being misinterpreted as list separator. These braces will be removed during processing. The list argument may be a macro `\MyList` expanding in one step to the comma separated list (if it has no arguments, it does not have to be braced). It will be expanded (only once) to reveal its comma separated items for processing, comma separated items will not be expanded before being fed into the replacement text as #1, or #2, etc..., only leading and trailing spaces are removed.

*\*fn* A starred variant `\xintFor*` deals with lists of braced items, rather than comma separated items. It has also a distinct expansion policy, which is detailed below.

Contrarily to what happens in loops where the item is represented by a macro, here it is truly exactly as when defining (in  $\text{\LaTeX}$ ) a “command” with parameters #1, etc... This

may avoid the user quite a few troubles with `\expandafters` or other `\edef/\noexpands` which one encounters at times when trying to do things with L<sup>A</sup>T<sub>E</sub>X's `\@for` or other loops which encapsulate the item in a macro expanding to that item.

The non-starred variant `\xintFor` deals with comma separated values (*spaces before and after the commas are removed*) and the comma separated list may be a macro which is only expanded once (to prevent expansion of the first item `\x` in a list directly input as `\x, \y, ...` it should be input as `{\x}, \y, ..` or `<space>\x, \y, ..`, naturally all of that within the mandatory braces of the `\xintFor #n in {list}` syntax). The items are not expanded, if the input is `<stuff>, \x, <stuff>` then `#1` will be at some point `\x` not its expansion (and not either a macro with `\x` as replacement text, just the token `\x`). Input such as `<stuff>, , <stuff>` creates an empty `#1`, the iteration is not skipped. An empty list does lead to the use of the replacement text, once, with an empty `#1` (or `#n`). Except if the entire list is represented as a single macro with no parameters, it must be braced.

The starred variant `\xintFor*` deals with token lists (*spaces between braced items or single tokens are not significant*) and *f-expands* each *unbraced* list item. This makes it easy to simulate concatenation of various list macros `\x, \y, ...` If `\x` expands to `{1}{2}{3}` and `\y` expands to `{4}{5}{6}` then `{\x\y}` as argument to `\xintFor*` has the same effect as `{\{1\}{2\}{3\}{4\}{5\}{6\}}`<sup>44</sup>. Spaces at the start, end, or in-between items are gobbled (but naturally not the spaces which may be inside *braced* items). Except if the list argument is a single macro with no parameters, it must be braced. Each item which is not braced will be fully expanded (as the `\x` and `\y` in the example above). An empty list leads to an empty result.

The macro `\xintSeq` which generates arithmetic sequences may only be used with `\xintFor*` (numbers from output of `\xintSeq` are braced, not separated by commas).

`\xintFor* #1 in {\xintSeq [+2]{-7}{+2}}\do {stuff with #1}` will have `#1=-7, -5, -3, -1, and 1`. The `#1` as issued from the list produced by `\xintSeq` is the literal representation as would be produced by `\arabic` on a L<sup>A</sup>T<sub>E</sub>X counter, it is not a count register. When used in `\ifnum` tests or other contexts where T<sub>E</sub>X looks for a number it should thus be postfixed with `\relax` or `\space`.

When nesting `\xintFor*` loops, using `\xintSeq` in the inner loops is inefficient, as the arithmetic sequence will be re-created each time. A more efficient style is:

```
\edef\innersequence {\xintSeq[+2]{-50}{50}}%
\xintFor* #1 in {\xintSeq {13}{27}} \do
  {\xintFor* #2 in \innersequence \do {stuff with #1 and #2}%
  .. some other macros .. }
```

This is a general remark applying for any nesting of loops, one should avoid recreating the inner lists of arguments at each iteration of the outer loop. However, in the example above, if the `.. some other macros ..` part closes a group which was opened before the `\edef\innersequence`, then this definition will be lost. An alternative to `\edef`, also

<sup>43</sup> braces around single token items are optional so this is the same as `{123456}`.

efficient, exists when dealing with arithmetic sequences: it is to use the `\xintintegers` keyword (described later) which simulates infinite arithmetic sequences; the loops will then be terminated via a test #1 (or #2 etc. . .) and subsequent use of `\xintBreakFor`.

The `\xintFor` loops are not completely expandable; but they may be nested and used inside alignments or other contexts where the replacement text closes groups. Here is an example (still using L<sup>A</sup>T<sub>E</sub>X's tabular):

```

A:  (a → A)  (b → A)  (c → A)  (d → A)  (e → A)
B:  (a → B)  (b → B)  (c → B)  (d → B)  (e → B)
C:  (a → C)  (b → C)  (c → C)  (d → C)  (e → C)

\begin{tabular}{rccccc}
\xintFor #7 in {A,B,C} \do {%
  #7:\xintFor* #3 in {abcde} \do {&($ #3 \to #7 $)}\\ }%
\end{tabular}
```

When inserted inside a macro for later execution the # characters must be doubled.<sup>44</sup> For example:

```

\def\T{\def\z {}}%
\xintFor* ##1 in {{u}{v}{w}} \do {%
  \xintFor ##2 in {x,y,z} \do {%
    \expandafter\def\expandafter\z\expandafter {\z\sep (##1,##2)} }%
}%
\T\def\sep {\def\sep{, }}\z
      (u,x), (u,y), (u,z), (v,x), (v,y), (v,z), (w,x), (w,y), (w,z)
```

Similarly when the replacement text of `\xintFor` defines a macro with parameters, the macro character # must be doubled.

It is licit to use inside an `\xintFor` a `\macro` which itself has been defined to use internally some other `\xintFor`. The same macro parameter #1 can be used with no conflict (as mentioned above, in the definition of `\macro` the # used in the `\xintFor` declaration must be doubled, as is the general rule in T<sub>E</sub>X with things defined inside other things).

The iterated commands as well as the list items are allowed to contain explicit `\par` tokens. Neither `\xintFor` nor `\xintFor*` create groups. The effect is like piling up the iterated commands with each time #1 (or #2 ...) replaced by an item of the list. However, contrarily to the completely expandable `\xintApplyUnbraced`, but similarly to the non completely expandable `\xintApplyInline` each iteration is executed first before looking at the next #1<sup>45</sup> (and the starred variant `\xintFor*` keeps on expanding each unbraced item it finds, gobbling spaces).

## 27.18 `\xintifForFirst`, `\xintifForLast`

*nn* ★ `\xintifForFirst {YES branch}{NO branch}` and `\xintifForLast {YES branch}{NO branch}` execute the YES or NO branch if the `\xintFor` or `\xintFor*` loop is currently in its first, respectively last, iteration.

<sup>44</sup> sometimes what seems to be a macro argument isn't really; in `\raisebox{1cm}{\xintFor #1 in {a,b,c}\do {#1}}` no doubling should be done. <sup>45</sup> to be completely honest, both `\xintFor` and `\xintFor*` initially scoop up both the list and the iterated commands; `\xintFor` scoops up a second time the entire comma separated list in order to feed it to `\xintCSVtoList`. The starred variant `\xintFor*` which does not need this step will thus be a bit faster on equivalent inputs.

Designed to work as expected under nesting. Don't forget an empty brace pair {} if a branch is to do nothing. May be used multiple times in the replacement text of the loop.

There is no such thing as an iteration counter provided by the `\xintFor` loops; the user is invited to define if needed his own count register or  $\text{\LaTeX}$  counter, for example with a suitable `\stepcounter` inside the replacement text of the loop to update it.

### 27.19 `\xintBreakFor`, `\xintBreakForAndDo`

One may immediately terminate an `\xintFor` or `\xintFor*` loop with `\xintBreakFor`. As the criterion for breaking will be decided on a basis of some test, it is recommended to use for this test the syntax of `ifthen`<sup>46</sup> or `etoolbox`<sup>47</sup> or the **xint** own conditionals, rather than one of the various `\if...\fi` of  $\text{\TeX}$ . Else (and this is without even mentioning all the various peculiarities of the `\if...\fi` constructs), one has to carefully move the break after the closing of the conditional, typically with `\expandafter\xintBreakFor\fi`.<sup>48</sup>

There is also `\xintBreakForAndDo`. Both are illustrated by various examples in the next section which is devoted to “forever” loops.

### 27.20 `\xintintegers`, `\xintdimensions`, `\xintrationals`

If the list argument to `\xintFor` (or `\xintFor*`, both are equivalent in this context) is `\xintintegers` (equivalently `\xintegers`) or more generally `\xintintegers[start+delta]` (*the whole within braces!*)<sup>49</sup>, then `\xintFor` does an infinite iteration where #1 (or #2, ..., #9) will run through the arithmetic sequence of (short) integers with initial value `start` and increment `delta` (default values: `start=1`, `delta=1`; if the optional argument is present it must contain both of them, and they may be explicit integers, or macros or count registers). The #1 (or #2, ..., #9) will stand for `\numexpr <opt sign><digits>\relax`, and the literal representation as a string of digits can thus be obtained as `\the#1` or `\number#1`. Such a #1 can be used in an `\ifnum` test with no need to be postfixed with a space or a `\relax` and one should *not* add them.

If the list argument is `\xintdimensions` or more generally `\xintdimensions[start+delta]` (*within braces!*), then `\xintFor` does an infinite iteration where #1 (or #2, ..., #9) will run through the arithmetic sequence of dimensions with initial value `start` and increment `delta`. Default values: `start=0pt`, `delta=1pt`; if the optional argument is present it must contain both of them, and they may be explicit specifications, or macros, or dimension registers, or length commands in  $\text{\LaTeX}$  (the stretch and shrink components will be discarded). The #1 will be `\dimexpr <opt sign><digits>sp\relax`, from which one can get the literal (approximate) representation in points via `\the#1`. So #1 can be used anywhere  $\text{\TeX}$  expects a dimension (and there is no need in conditionals to insert a `\relax`, and one should *not* do it), and to print its value one uses `\the#1`. The chosen representation guarantees exact incrementation with no rounding errors accumulating from converting into points at each step.

<sup>46</sup> <http://ctan.org/pkg/ifthen> <sup>47</sup> <http://ctan.org/pkg/etoolbox> <sup>48</sup> the difficulties here are similar to those mentioned in section 14, although less severe, as complete expandability is not to be maintained; hence the allowed use of `ifthen`. <sup>49</sup> the `start+delta` optional specification may have extra spaces around the plus sign of near the square brackets, such spaces are removed. The same applies with `\xintdimensions` and `\xintrationals`.



```
\def\DimToNum #1{\number\dimexpr #1\relax }
\xintNewNumExpr \FA [2] {\_DimToNum {#2}}^3/{\_DimToNum {#1}}^2} % cube
\xintNewNumExpr \FB [2] {\sqrt {\_DimToNum {#2}}*\_DimToNum {#1}} % sqrt
\xintNewExpr \Ratio [2] {\trunc{\_DimToNum {#2}}/{\_DimToNum {#1}},3)}
\xintFor #1 in {\xintdimensions [0pt+.1pt]} \do
{\ifdim #1>2cm \expandafter\xintBreakFor\fi
 {\color [rgb]{\Ratio {2cm}{#1}},0,0}%
 \vrule width .1pt height \FB {2cm}{#1}sp depth -\FA {2cm}{#1}sp }%
}% end of For iterated text
```

The **graphic**, with the code on its right<sup>50</sup>, is for illustration only, not only because of pdf rendering artefacts when displaying adjacent rules (which do *not* show in dvi output as rendered by xdvi, and depend from your viewer), but because not using anything but rules it is quite inefficient and must do lots of computations to not confer a too ragged look to the borders. With a width of .5pt rather than .1pt for the rules, one speeds up the drawing by a factor of five, but the boundary is then visibly ragged.<sup>51</sup>

If the list argument to **\xintFor** (or **\xintFor\***) is **\xintrationals** or more generally **\xintrationals**[start+delta] (*within braces!*), then **\xintFor** does an infinite iteration where #1 (or #2, ..., #9) will run through the arithmetic sequence of **xintfrac** fractions with initial value start and increment delta (default values: start=1/1, delta=1/1). This loop works *only with xintfrac loaded*. if the optional argument is present it must contain both of them, and they may be given in any of the formats recognized by **xintfrac** (fractions, decimal numbers, numbers in scientific notations, numerators and denominators in scientific notation, etc...) , or as macros or count registers (if they are short integers). The #1 (or #2, ..., #9) will be an a/b fraction (without a [n] part), where the denominator b is the product of the denominators of start and delta (for reasons of speed #1 is not reduced to irreducible form, and for another reason explained later start and delta are not put either into irreducible form; the input may use explicitly **\xintIrr** to achieve that).

```
\xintFor #1 in {\xintrationals [10/21+1/21]} \do
{#1=\xintifInt {#1}
 {\textcolor{blue}{\xintTrunc{10}{#1}}}
 {\xintTrunc{10}{#1}}% in blue if an integer
 \xintifGt {#1}{1.123}{\xintBreakFor}{, }%
}
10/21=0.4761904761, 11/21=0.5238095238, 12/21=0.5714285714, 13/21=0.6190476190,
14/21=0.6666666666, 15/21=0.7142857142, 16/21=0.7619047619, 17/21=0.8095238095,
18/21=0.8571428571, 19/21=0.9047619047, 20/21=0.9523809523, 21/21=1.0000000000,
22/21=1.0476190476, 23/21=1.0952380952, 24/21=1.1428571428
```

The example above confirms that computations are done exactly, and illustrates that the two initial (reduced) denominators are not multiplied when they are found to be equal. It

<sup>50</sup> the somewhat peculiar use of \_ and \$ is explained in [subsection 30.6](#); they are made necessary from the fact that the parameters are passed to a *macro* (**\DimToNum**) and not only to *functions*, as are known to **\xintexpr**. But one can also define directly the desired function, for example the constructed **\FA** turns out to have meaning macro: #1#2->\romannumeral -'0\xintiRound 0{\xintDiv {\xintPow {\\_DimToNum {#2}}{3}}{\xintPow {\\_DimToNum {#1}}{2}}}, where the \romannumeral part is only to ensure it expands in only two steps, and could be removed. A handwritten macro would use here **\xintiPow** and not **\xintPow**, as we know it has to deal with integers only. See the next footnote.

<sup>51</sup> to tell the whole truth we cheated and divided by 10 the computation time through using the following definitions, together with a horizontal step of .25pt rather than .1pt. The displayed original code would make the slowest computation of all those done in this document using the **xint** bundle

```
\def\DimToNum #1{\the\numexpr \dimexpr#1\relax/10000\relax } % no need to be more precise!
\def\FA #1#2{\xintDSH {-4}{\xintQuo {\xintiPow {\_DimToNum {#2}}{3}}{\xintiSqr {\_DimToNum {#1}}}}}
\def\FB #1#2{\xintDSH {-4}{\xintiSqr {\xintiMul {\_DimToNum {#2}}{\_DimToNum {#1}}}}}
\def\Ratio #1#2{\xintTrunc {2}{\_DimToNum {#2}}/{\_DimToNum {#1}}}
\xintFor #1 in {\xintdimensions [0pt+.25pt]} \do
{\ifdim #1>2cm \expandafter\xintBreakFor\fi
 {\color [rgb]{\Ratio {2cm}{#1}},0,0}%
 \vrule width .25pt height \FB {2cm}{#1}sp depth -\FA {2cm}{#1}sp }%
}% end of For iterated text
```

macros!

is thus recommended to input `start` and `delta` with a common smallest possible denominator, or as fixed point numbers with the same numbers of digits after the decimal mark; and this is also the reason why `start` and `delta` are not by default made irreducible. As internally the computations are done with numerators and denominators completely expanded, one should be careful not to input numbers in scientific notation with exponents in the hundreds, as they will get converted into as many zeros.

```
\xintFor #1 in {\xintrationals [0.000+0.125]} \do
{\edef\tmp{\xintTrunc{3}{#1}}%
\xintifInt {#1}
  {\textcolor{blue}{\tmp}}
  {\tmp}%
\xintifGt {#1}{2}{\xintBreakFor}{, }%
}
0, 0.125, 0.250, 0.375, 0.500, 0.625, 0.750, 0.875, 1.000, 1.125, 1.250,
1.375, 1.500, 1.625, 1.750, 1.875, 2.000, 2.125
```

We see here that `\xintTrunc` outputs (deliberately) zero as 0, not (here) 0.000, the idea being not to lose the information that the truncated thing was truly zero. Perhaps this behavior should be changed? or made optional? Anyhow printing of fixed points numbers should be dealt with via dedicated packages such as `numprint` or `siunitx`.

## 27.21 Another table of primes

As a further example, let us dynamically generate a tabular with the first 50 prime numbers after 12345. First we need a macro to test if a (short) number is prime. Such a completely expandable macro was given in [subsection 27.10](#), here we consider a variant which will be slightly more efficient. This new `\IsPrime` has two parameters. The first one is a macro which it redefines to expand to the result of the primality test applied to the second argument. For convenience we use the `etoolbox` wrappers to various `\ifnum` tests, although here there isn't anymore the constraint of complete expandability (but using explicit `\if. . \fi` in tabulars has its quirks); equivalent tests are provided by **xint**, but they have some overhead as they are able to deal with arbitrarily big integers.

```
\def\IsPrime #1#2% #1=\Result, #2=tested number (assumed >0).
{\edef\TheNumber {\the\numexpr #2}% hence #2 may be a count or \numexpr.
\xifnumodd {\TheNumber}
{\ifnumgreater {\TheNumber}{1}
  {\edef\ItsSquareRoot{\xintiSqrt \TheNumber}%
  \xintFor ##1 in {\xintintegers [3+2]}\do
  {\ifnumgreater {##1}{\ItsSquareRoot} % ##1 is a \numexpr.
    {\def#1{1}\xintBreakFor}
    {}}%
  \ifnumequal {\TheNumber}{(\TheNumber/##1)*##1}
  {\def#1{0}\xintBreakFor }
  {}}%
  {}%
  {\def#1{0}}}% 1 is not prime
{\ifnumequal {\TheNumber}{2}{\def#1{1}}{\def#1{0}}}%
}
```

As we used `\xintFor` inside a macro we had to double the `#` in its `#1` parameter. Here is now the code which creates the prime table (the table has been put in a `float`, which appears on the next page):

12347	12373	12377	12379	12391	12401	12409
12413	12421	12433	12437	12451	12457	12473
12479	12487	12491	12497	12503	12511	12517
12527	12539	12541	12547	12553	12569	12577
12583	12589	12601	12611	12613	12619	12637
12641	12647	12653	12659	12671	12689	12697
12703	12713	12721	12739	12743	12757	12763
12781	These are the first 50 primes after 12345.					

```

\newcounter{primecount}
\newcounter{cellcount}
\begin{figure*}[ht!]
  \centering
  \begin{tabular}{|*{7}c|}
    \hline
    \setcounter{primecount}{0}\setcounter{cellcount}{0}%
    \xintFor #1 in {\xintintegers [12345+2]} \do
    % #1 is a \numexpr.
    {\IsPrime\Result{#1}%
     \ifnumgreater{\Result}{0}
     {\stepcounter{primecount}%
      \stepcounter{cellcount}%
      \ifnumequal {\value{cellcount}}{7}
       {\the#1 \\ \setcounter{cellcount}{0}}
       {\the#1 &}}
     {}%
     \ifnumequal {\value{primecount}}{50}
     {\xintBreakForAndDo
      {\multicolumn {6}{l|}{These are the first 50 primes after 12345.}}\\
      {}%
     }\hline
  \end{tabular}
\end{figure*}

```

## 27.22 Some arithmetic with Fibonacci numbers

Here is again the code employed on the title page to compute Fibonacci numbers:

```

\def\Fibonacci #1{% \Fibonacci{N} computes F(N) with F(0)=0, F(1)=1.
  \expandafter\Fibonacci_a\expandafter
    {\the\numexpr #1\expandafter}\expandafter
    {\romannumeral0\xintiieval 1\expandafter\relax\expandafter}\expandafter
    {\romannumeral0\xintiieval 1\expandafter\relax\expandafter}\expandafter
    {\romannumeral0\xintiieval 0\expandafter\relax\expandafter}\expandafter
    {\romannumeral0\xintiieval 1\expandafter\relax\expandafter}\expandafter
    {\romannumeral0\xintiieval 0\expandafter\relax\expandafter}\expandafter
    {\romannumeral0\xintiieval 1\relax}}
%
\def\Fibonacci_a #1{%
  \ifcase #1
    \expandafter\Fibonacci_end_i
  \or
    \expandafter\Fibonacci_end_ii
  \else

```

```

\ifodd #1
  \expandafter\expandafter\expandafter\Fibonacci_b_ii
\else
  \expandafter\expandafter\expandafter\Fibonacci_b_i
\fi
\fi {#1}%
}% (* signs omitted from the next macros, 1.09j has tacit multiplication)
\def\Fibonacci_b_i #1#2#3#4{\expandafter\Fibonacci_a\expandafter
  {\the\numexpr #1/2\expandafter}\expandafter
  {\romannumeral0\xintiieval sqr(#2)+sqr(#3)\expandafter\relax\expandafter}\expandafter
  {\romannumeral0\xintiieval (#2+#4)#3\expandafter\relax\expandafter}\expandafter
  {\romannumeral0\xintiieval sqr(#3)+sqr(#4)\relax}%
}% end of Fibonacci_b_i
\def\Fibonacci_b_ii #1#2#3#4#5#6#7{\expandafter\Fibonacci_a\expandafter
  {\the\numexpr (#1-1)/2\expandafter}\expandafter
  {\romannumeral0\xintiieval sqr(#2)+sqr(#3)\expandafter\relax\expandafter}\expandafter
  {\romannumeral0\xintiieval (#2+#4)#3\expandafter\relax\expandafter}\expandafter
  {\romannumeral0\xintiieval sqr(#3)+sqr(#4)\expandafter\relax\expandafter}\expandafter
  {\romannumeral0\xintiieval #2#5+#3#6\expandafter\relax\expandafter}\expandafter
  {\romannumeral0\xintiieval #2#6+#3#7\expandafter\relax\expandafter}\expandafter
  {\romannumeral0\xintiieval #3#6+#4#7\relax}%
}% end of Fibonacci_b_ii
\def\Fibonacci_end_i #1#2#3#4#5#6#7{{#5}{#6}}% {F(N+1)}{F(N)} in \xintexpr format
\def\Fibonacci_end_ii #1#2#3#4#5#6#7%
  {\expandafter
   {\romannumeral0\xintiieval #2#5+#3#6\expandafter\relax
    \expandafter}\expandafter
   {\romannumeral0\xintiieval #2#6+#3#7\relax}}% idem.
% \FibonacciN returns F(N) (also in encapsulated format: needs \xintthe for printing)
\def\FibonacciN {\expandafter\xint_secondoftwo\romannumeral-'\0\Fibonacci}%

```

I have modified the ending, as I now want not only one specific value  $F(N)$  but a pair of successive values which can serve as starting point of another routine devoted to compute a whole sequence  $F(N)$ ,  $F(N+1)$ ,  $F(N+2)$ , .... This pair is, for efficiency, kept in the encapsulated internal *xintexpr* format. `\FibonacciN` outputs the single  $F(N)$ , also as an *xintexpr*-expression, and printing it will thus need the `\xintthe` prefix.

Here a code snippet which checks the routine via a `\message` of the first 51 Fibonacci numbers (this is not an efficient way to generate a sequence of such numbers, it is only for validating `\FibonacciN`).

```

\def\Fibo #1.{\xintthe\FibonacciN {#1}}%
\message{\xintloop [0+1] \expandafter\Fibo\xintloopindex.,
  \ifnum\xintloopindex<49 \repeat \xintthe\FibonacciN{50}.}

```

The various `\romannumeral0\xintiieval` could very well all have been `\xintiexpr`'s but then we would have needed more `\expandafter`'s. Indeed the order of expansion must be controlled for the whole thing to work, and `\romannumeral0\xintiieval` is the first expanded form of `\xintiexpr`.

The way we use `\expandafter`'s to chain successive *xintexpr* evaluations is exactly analogous to well-known expandable techniques made possible by `\numexpr`.

There is a difference though: `\numexpr` is *NOT* expandable, and to force its expansion we must prefix it with `\the` or `\number`. On the other hand `\xintexpr`, `\xintiexpr`, ..., (or `\xinteval`, `\xintiieval`, ...) expand fully when prefixed by `\romannumeral-'\0`: the computation is fully executed and its result encapsulated in a private format.

Using `\xintthe` as prefix is necessary to print the result (this is like `\the` for `\numexpr`), but it is not necessary to get the computation done (contrarily to the situation with `\numexpr`).

And, starting with release 1.09j, it is also allowed to expand a non `\xintthe` prefixed `\xintexpr` inside an `\edef`: the private format is now protected, hence the error message complaining about a missing `\xintthe` will not be executed, and the integrity of the format will be preserved.

This new possibility brings some efficiency gain, when one writes non-expandable algorithms using *xintexpr*. If `\xintthe` is employed inside `\edef` the number or fraction will be un-locked into its possibly hundreds of digits and all these tokens will possibly weigh on the upcoming shuffling of (braced) tokens. The private encapsulated format has only a few tokens, hence expansion will proceed a bit faster.

see footnote<sup>52</sup>

Our `\Fibonacci` expands completely under *f*-expansion, so we can use `\fdef` rather than `\edef` in a situation such as

```
\fdef \X {\FibonacciN {100}}
```

but for the reasons explained above, it is as efficient to employ `\edef`. And if we want

```
\edef \Y {\FibonacciN{100},\FibonacciN{200}},
```

then `\edef` is necessary.

Allright, so let's now give the code to generate a sequence of braced Fibonacci numbers `{F(N)}{F(N+1)}{F(N+2)}...`, using `\Fibonacci` for the first two and then using the standard recursion  $F(N+2)=F(N+1)+F(N)$ :

```
\catcode'\_ 11
\def\FibonacciSeq #1#2{%
  \expandafter\Fibonacci_Seq\expandafter
  {\the\numexpr #1\expandafter}\expandafter{\the\numexpr #2-1}%
}%
\def\Fibonacci_Seq #1#2{%
  \expandafter\Fibonacci_Seq_loop\expandafter
  {\the\numexpr #1\expandafter}\romannumeral0\Fibonacci {#1}{#2}%
}%
\def\Fibonacci_Seq_loop #1#2#3#4{% standard Fibonacci recursion
  {#3}\unless\ifnum #1<#4 \Fibonacci_Seq_end\fi
  \expandafter\Fibonacci_Seq_loop\expandafter
  {\the\numexpr #1+1\expandafter}\expandafter
  {\romannumeral0\xintiieval #2+#3\relax}{#2}{#4}%
}%
\def\Fibonacci_Seq_end\fi\expandafter\Fibonacci_Seq_loop\expandafter
  #1\expandafter #2#3#4{\fi {#3}}%
\catcode'\_ 8
```

<sup>52</sup> To be completely honest the examination by T<sub>E</sub>X of all successive digits was not avoided, as it occurs already in the locking-up of the result, what is avoided is to spend time un-locking, and then have the macros shuffle around possibly hundreds of digit tokens rather than a few control words. Technical note: I decided (somewhat hesitantly) for reasons of optimization purposes to skip in the private `\xintexpr` format a `\protect`-ion for the `\.=digits/digits[digits]` control sequences used internally. Thus in the improbable case that some macro package (such control sequence names are unavailable to the casual user) has given a meaning to one such control sequence, there is a possibility of a crash when embedding an `\xintexpr` without `\xintthe` prefix in an `\edef` (the computations by themselves do proceed perfectly correctly even if these control sequences have acquired some non `\relax` meaning).

Deliberately and for optimization, this `\FibonacciSeq` macro is completely expandable but not *f*-expandable. It would be easy to modify it to be so. But I wanted to check that the `\xintFor*` does apply full expansion to what comes next each time it fetches an item from its list argument. Thus, there is no need to generate lists of braced Fibonacci numbers beforehand, as `\xintFor*`, without using any `\edef`, still manages to generate the list via iterated full expansion.

I initially used only one `\halign` in a three-column `multicols` environment, but `multicols` only knows to divide the page horizontally evenly, thus I employed in the end one `\halign` for each column (I could have then used a `tabular` as no column break was then needed).

30.	832040	0	60.	1548008755920	0	90.	2880067194370816120	0
31.	1346269	514229	61.	2504730781961	1	91.	4660046610375530309	514229
32.	2178309	514229	62.	4052739537881	1	92.	7540113804746346429	514229
33.	3524578	196418	63.	6557470319842	2	93.	12200160415121876738	196418
34.	5702887	710647	64.	10610209857723	3	94.	19740274219868223167	710647
35.	9227465	75025	65.	17167680177565	5	95.	31940434634990099905	75025
36.	14930352	785672	66.	27777890035288	8	96.	51680708854858323072	785672
37.	24157817	28657	67.	44945570212853	13	97.	83621143489848422977	28657
38.	39088169	814329	68.	72723460248141	21	98.	135301852344706746049	814329
39.	63245986	10946	69.	117669030460994	34	99.	218922995834555169026	10946
40.	102334155	825275	70.	190392490709135	55	100.	354224848179261915075	825275
41.	165580141	4181	71.	308061521170129	89	101.	573147844013817084101	4181
42.	267914296	829456	72.	498454011879264	144	102.	927372692193078999176	829456
43.	433494437	1597	73.	806515533049393	233	103.	1500520536206896083277	1597
44.	701408733	831053	74.	1304969544928657	377	104.	2427893228399975082453	831053
45.	1134903170	610	75.	2111485077978050	610	105.	3928413764606871165730	610
46.	1836311903	831663	76.	3416454622906707	987	106.	6356306993006846248183	831663
47.	2971215073	233	77.	5527939700884757	1597	107.	10284720757613717413913	233
48.	4807526976	831896	78.	8944394323791464	2584	108.	16641027750620563662096	831896
49.	7778742049	89	79.	14472334024676221	4181	109.	26925748508234281076009	89
50.	12586269025	831985	80.	23416728348467685	6765	110.	43566776258854844738105	831985
51.	20365011074	34	81.	37889062373143906	10946	111.	70492524767089125814114	34
52.	32951280099	832019	82.	61305790721611591	17711	112.	114059301025943970552219	832019
53.	53316291173	13	83.	99194853094755497	28657	113.	184551825793033096366333	13
54.	86267571272	832032	84.	160500643816367088	46368	114.	298611126818977066918552	832032
55.	139583862445	5	85.	259695496911122585	75025	115.	483162952612010163284885	5
56.	225851433717	832037	86.	420196140727489673	121393	116.	781774079430987230203437	832037
57.	365435296162	2	87.	679891637638612258	196418	117.	1264937032042997393488322	2
58.	591286729879	832039	88.	1100087778366101931	317811	118.	2046711111473984623691759	832039
59.	956722026041	1	89.	1779979416004714189	514229	119.	3311648143516982017180081	1

Some Fibonacci numbers together with their residues modulo  $F(30)=832040$

```
\newcounter{index}
\tabskip 1ex
\def\Fibxxx{\FibonacciN {30}}%
\setcounter{index}{30}%
\vbox{\halign{\bfseries#. \hfil &# \hfil &\hfil #\cr
```

```

\intFor* #1 in {\FibonacciSeq {30}{59}}\do
{\theindex &\xintthe#1 &
  \xintRem{\xintthe#1}{\xintthe\Fibxxx}\stepcounter{index}\cr }%
}\vrule
\vbbox{\halign{\bfseries#.\hfil&\hfil &\hfil #\cr
  \intFor* #1 in {\FibonacciSeq {60}{89}}\do
  {\theindex &\xintthe#1 &
    \xintRem{\xintthe#1}{\xintthe\Fibxxx}\stepcounter{index}\cr }%
}\vrule
\vbbox{\halign{\bfseries#.\hfil&\hfil &\hfil #\cr
  \intFor* #1 in {\FibonacciSeq {90}{119}}\do
  {\theindex &\xintthe#1 &
    \xintRem{\xintthe#1}{\xintthe\Fibxxx}\stepcounter{index}\cr }%
}%

```

This produces the Fibonacci numbers from F(30) to F(119), and computes also all the congruence classes modulo F(30). The output has been put in a [float](#), which appears on the preceding page. I leave to the mathematically inclined readers the task to explain the visible patterns...;-).

### 27.23 **\xintForpair**, **\xintForthree**, **\xintForfour**

*on* The syntax is illustrated in this example. The notation is the usual one for n-uples, with parentheses and commas. Spaces around commas and parentheses are ignored.

```

\begin{tabular}{cccc}
  \xintForpair #1#2 in { ( A , a ) , ( B , b ) , ( C , c ) } \do {%
    \xintForpair #3#4 in { ( X , x ) , ( Y , y ) , ( Z , z ) } \do {%
      $\Biggl(\begin{tabular}{cc}
        -#1- & -#3-\\
        -#4- & -#2-\\
      \end{tabular}\Biggr)$&\\noalign{\vskip1\jot}}%
    }%
  }%
\end{tabular}

```

$$\begin{pmatrix} -A- & -X- \\ -x- & -a- \end{pmatrix} \quad \begin{pmatrix} -A- & -Y- \\ -y- & -a- \end{pmatrix} \quad \begin{pmatrix} -A- & -Z- \\ -z- & -a- \end{pmatrix} \\
 \begin{pmatrix} -B- & -X- \\ -x- & -b- \end{pmatrix} \quad \begin{pmatrix} -B- & -Y- \\ -y- & -b- \end{pmatrix} \quad \begin{pmatrix} -B- & -Z- \\ -z- & -b- \end{pmatrix} \\
 \begin{pmatrix} -C- & -X- \\ -x- & -c- \end{pmatrix} \quad \begin{pmatrix} -C- & -Y- \\ -y- & -c- \end{pmatrix} \quad \begin{pmatrix} -C- & -Z- \\ -z- & -c- \end{pmatrix}$$

Only #1#2, #2#3, #3#4, ..., #8#9 are valid (no error check is done on the input syntax, #1#3 or similar all end up in errors). One can nest with **\xintFor**, for disjoint sets of macro parameters. There is also **\xintForthree** (from #1#2#3 to #7#8#9) and **\xintForfour** (from #1#2#3#4 to #6#7#8#9). **\par** tokens are accepted in both the comma separated list and the replacement text.

### 27.24 **\xintAssign**

**\xintAssign***<braced things>***\to***<as many cs as they are things>* defines (without checking if something gets overwritten) the control sequences on the right of **\to** to expand to the successive tokens or braced items found one after the other on the left of **\to**. It is not expandable.

A ‘full’ expansion is first applied to the material in front of `\xintAssign`, which may thus be a macro expanding to a list of braced items.

Special case: if after this initial expansion no brace is found immediately after `\xintAssign`, it is assumed that there is only one control sequence following `\to`, and this control sequence is then defined via `\def` to expand to the material between `\xintAssign` and `\to`. Other types of expansions are specified through an optional parameter to `\xintAssign`, see *infra*.

```
\xintAssign \xintDivision{1000000000000}{133333333}\to\Q\R
\meaning\Q: macro:->7500, \meaning\R: macro:->2500
\xintAssign \xintiPow {7}{13}\to\SevenToThePowerThirteen
\SevenToThePowerThirteen=96889010407
(same as \edef\SevenToThePowerThirteen{\xintiPow {7}{13}})
```

Changed! → `\xintAssign` admits since 1.09i an optional parameter, for example `\xintAssign [e]...` or `\xintAssign [oo] ...`. The latter means that the definitions of the macros initially on the right of `\to` will be made with `\oodef` which expands twice the replacement text. The default is simply to make the definitions with `\def`, corresponding to an empty optional parameter `[]`. Possibilities: `[]`, `[g]`, `[e]`, `[x]`, `[o]`, `[go]`, `[oo]`, `[goo]`, `[f]`, `[gf]`.

In all cases, recall that `\xintAssign` starts with an *f*-expansion of what comes next; this produces some list of tokens or braced items, and the optional parameter only intervenes to decide the expansion type to be applied then to each one of these items.

*Note:* prior to release 1.09j, `\xintAssign` did an `\edef` by default, but it now does `\def`. Use the optional parameter `[e]` to force use of `\edef`.

## 27.25 `\xintAssignArray`

`\xintAssignArray`(*braced things*)`\to\myArray` first expands fully what comes immediately after `\xintAssignArray` and expects to find a list of braced things `{A}{B}...` (or tokens). It then defines `\myArray` as a macro with one parameter, such that `\myArray{x}` expands to give the *x*th braced thing of this original list (the argument `{x}` itself is fed to a `\numexpr` by `\myArray`, and `\myArray` expands in two steps to its output). With `0` as parameter, `\myArray{0}` returns the number *M* of elements of the array so that the successive elements are `\myArray{1}`, ..., `\myArray{M}`.

```
\xintAssignArray \xintBezout {1000}{113}\to\Bez
```

will set `\Bez{0}` to 5, `\Bez{1}` to 1000, `\Bez{2}` to 113, `\Bez{3}` to -20, `\Bez{4}` to -177, and `\Bez{5}` to 1:  $(-20) \times 1000 - (-177) \times 113 = 1$ . This macro is incompatible with expansion-only contexts.

Changed! → `\xintAssignArray` admits now an optional parameter, for example `\xintAssignArray [e]...`. This means that the definitions of the macros will be made with `\edef`. The default is `[]`, which makes the definitions with `\def`. Other possibilities: `[]`, `[o]`, `[oo]`, `[f]`. Contrarily to `\xintAssign` one can not use the *g* here to make the definitions global. For this, one should rather do `\xintAssignArray` within a group starting with `\globaldefs` 1.

Note that prior to release 1.09j each item (token or braced material) was submitted to an `\edef`, but the default is now to use `\def`.

**27.26 \xintRelaxArray**

`\xintRelaxArray\myArray` (globally) sets to `\relax` all macros which were defined by the previous `\xintAssignArray` with `\myArray` as array macro.

**27.27 \odef, \oodef, \fdef**

`\oodef\controlsequence {<stuff>}` does

```
\expandafter\expandafter\expandafter\def
\expandafter\expandafter\expandafter\controlsequence
\expandafter\expandafter\expandafter{<stuff>}
```

This works only for a single `\controlsequence`, with no parameter text, even without parameters. An alternative would be:

```
\def\oodef #1#{\def\oodefparametertext{#1}%
\expandafter\expandafter\expandafter\expandafter
\expandafter\expandafter\expandafter\def
\expandafter\expandafter\expandafter\oodefparametertext
\expandafter\expandafter\expandafter }
```

but it does not allow `\global` as prefix, and, besides, would have anyhow its use (almost) limited to parameter texts without macro parameter tokens (except if the expanded thing does not see them, or is designed to deal with them).

There is a similar macro `\odef` with only one expansion of the replacement text `<stuff>`, and `\fdef` which expands fully `<stuff>` using `\romannumeral-‘0`.

These tools are provided as it is sometimes wasteful (from the point of view of running time) to do an `\edef` when one knows that the contents expand in only two steps for example, as is the case with all (except `\xintloop` and `\xintilooop`) the expandable macros of the **xint** packages. Each will be defined only if **xinttools** finds them currently undefined. They can be prefixed with `\global`.

**27.28 The Quick Sort algorithm illustrated**

First a completely expandable macro which sorts a list of numbers. The `\QSfull` macro expands its list argument, which may thus be a macro; its items must expand to possibly big integers (or also decimal numbers or fractions if using **xintfrac**), but if an item is expressed as a computation, this computation will be redone each time the item is considered! If the numbers have many digits (i.e. hundreds of digits...), the expansion of `\QSfull` is fastest if each number, rather than being explicitly given, is represented as a single token which expands to it in one step.

If the interest is only in  $\text{\TeX}$  integers, then one should replace the macros `\QSMORE`, `\QSEqual`, `\QSLess` with versions using the **etoolbox** ( $\text{\LaTeX}$  only) `\ifnumgreater`, `\ifnumequal` and `\ifnumless` conditionals rather than `\xintifGt`, `\xintifEq`, `\xintifLt`.

```
% THE QUICK SORT ALGORITHM EXPANDABLY
\input xintfrac.sty
% HELPER COMPARISON MACROS
\def\QSMORE #1#2{\xintifGt {#2}{#1}{#{#2}}{ }}
% the spaces are there to stop the \romannumeral-‘0 originating
% in \xintapplyunbraced when it applies a macro to an item
\def\QSEqual #1#2{\xintifEq {#2}{#1}{#{#2}}{ }}
```

```

\def\QSLess #1#2{\xintifLt {#2}{#1}{{#2}}{ }}
%
\makeatletter
\def\QSfull {\romannumeral0\qsfull }
\def\qsfull #1{\expandafter\qsfull@a\expandafter{\romannumeral-‘0#1}}
\def\qsfull@a #1{\expandafter\qsfull@b\expandafter {\xintLength {#1}}{#1}}
\def\qsfull@b #1{\ifcase #1
    \expandafter\qsfull@empty
  \or\expandafter\qsfull@single
  \else\expandafter\qsfull@c
  \fi
}%
\def\qsfull@empty #1{ } % the space stops the \QSfull \romannumeral0
\def\qsfull@single #1{ #1}
% for simplicity of implementation, we pick up the first item as pivot
\def\qsfull@c #1{\qsfull@ci #1\undef {#1}}
\def\qsfull@ci #1#2\undef {\qsfull@d {#1}}% #3 is the list, #1 its first item
\def\qsfull@d #1#2{\expandafter\qsfull@e\expandafter
    {\romannumeral0\qsfull
    {\xintApplyUnbraced {\QSMORE {#1}}{#2}}}%
    {\romannumeral0\xintapplyunbraced {\QSEQUAL {#1}}{#2}}}%
    {\romannumeral0\qsfull
    {\xintApplyUnbraced {\QSLess {#1}}{#2}}}%
}%
\def\qsfull@e #1#2#3{\expandafter\qsfull@f\expandafter {#2}{#3}{#1}}%
\def\qsfull@f #1#2#3{\expandafter\space #2#1#3}
\makeatother
% EXAMPLE
\edef\z {\QSfull {{1.0}{0.5}{0.3}{1.5}{1.8}{2.0}{1.7}{0.4}{1.2}{1.4}%
    {1.3}{1.1}{0.7}{1.6}{0.6}{0.9}{0.8}{0.2}{0.1}{1.9}}}
\tt\meaning\z
\def\A {3.123456789123456789}\def\B {3.123456789123456788}
\def\C {3.123456789123456790}\def\D {3.123456789123456787}
\expandafter\def\expandafter\z\expandafter
    {\romannumeral0\qsfull {{\A}\B\C\D}}% \A is braced to not be expanded
\meaning\z

```

Output:

```
macro:->{0.1}{0.2}{0.3}{0.4}{0.5}{0.6}{0.7}{0.8}{0.9}{1.0}{1.1}{1.2}{
1.3}{1.4}{1.5}{1.6}{1.7}{1.8}{1.9}{2.0}
```

```
macro:->{\D}{\B}{\A}{\C}
```

We then turn to a graphical illustration of the algorithm. For simplicity the pivot is always chosen to be the first list item. We also show later how to illustrate the variant which picks up the last item of each unsorted chunk as pivot.

```

\input xintfrac.sty % if Plain TeX
%
\definecolor{LEFT}{RGB}{216,195,88}
\definecolor{RIGHT}{RGB}{208,231,153}
\definecolor{INERT}{RGB}{199,200,194}
\definecolor{PIVOT}{RGB}{109,8,57}
%

```

```

\def\QSMORE #1#2{\xintifGt {#2}{#1}{{#2}}{ }}% space will be gobbled
\def\QSEQUAL #1#2{\xintifEq {#2}{#1}{{#2}}{ }}
\def\QSLess #1#2{\xintifLt {#2}{#1}{{#2}}{ }}
%
\makeatletter
\def\QS@a #1{\expandafter \QS@b \expandafter {\xintLength {#1}}{#1}}
\def\QS@b #1{\ifcase #1
      \expandafter\QS@empty
    \or\expandafter\QS@single
    \else\expandafter\QS@c
    \fi
}%
\def\QS@empty #1{}
\def\QS@single #1{\QSIr {#1}}
\def\QS@c #1{\QS@d #1!{#1}} % we pick up the first as pivot.
\def\QS@d #1#2!\QS@e {#1}}% #1 = first element, #3 = list
\def\QS@e #1#2{\expandafter\QS@f\expandafter
      {\romannumeral0\xintapplyunbraced {\QSMORE {#1}}{#2}}%
      {\romannumeral0\xintapplyunbraced {\QSEQUAL {#1}}{#2}}%
      {\romannumeral0\xintapplyunbraced {\QSLess {#1}}{#2}}%
}%
\def\QS@f #1#2#3{\expandafter\QS@g\expandafter {#2}{#3}{#1}}%
% Here \QSLr, \QSIr, \QSRr have been let to \relax, so expansion stops.
% #2= elements < pivot, #1 = elements = pivot, #3 = elements > pivot
\def\QS@g #1#2#3{\QSLr {#2}\QSIr {#1}\QSRr {#3}}%
%
\def\DecoLEFT #1{\xintFor* ##1 in {#1} \do {\colorbox{LEFT}{##1}}}
\def\DecoINERT #1{\xintFor* ##1 in {#1} \do {\colorbox{INERT}{##1}}}
\def\DecoRIGHT #1{\xintFor* ##1 in {#1} \do {\colorbox{RIGHT}{##1}}}
\def\DecoPivot #1{\begingroup\color{PIVOT}\advance\fbboxsep-\fbboxrule
      \fbbox{#1}\endgroup}
\def\DecoLEFTwithPivot #1{%
  \xintFor* ##1 in {#1} \do
    {\xintifForFirst {\DecoPivot {##1}}{\colorbox{LEFT}{##1}}}%
}
\def\DecoRIGHTwithPivot #1{%
  \xintFor* ##1 in {#1} \do
    {\xintifForFirst {\DecoPivot {##1}}{\colorbox{RIGHT}{##1}}}%
}
%
\def\QSinitialize #1{\def\QS@list{\QSRr {#1}}%
      \let\QSRr\DecoRIGHT
%
      \QS@list \par
\par\centerline{\QS@list}
}
\def\QSoneStep {\let\QSLr\DecoLEFTwithPivot
      \let\QSIr\DecoINERT
      \let\QSRr\DecoRIGHTwithPivot
%
      \QS@list
\centerline{\QS@list}
%
      \par
\def\QSLr {\noexpand\QS@a}%

```

```

\let\QSIr\relax
\def\QSRr {\noexpand\QS@a}%
  \edef\QS@list{\QS@list}%
\let\QSLr\relax
\let\QSRr\relax
  \edef\QS@list{\QS@list}%
\let\QSLr\DecoLEFT
\let\QSIr\DecoINERT
\let\QSRr\DecoRIGHT
%
  \QS@list
\centerline{\QS@list}
%
  \par
}
\begingroup\offinterlineskip
\small
\QSinitialize {{1.0}{0.5}{0.3}{1.5}{1.8}{2.0}{1.7}{0.4}{1.2}{1.4}%
               {1.3}{1.1}{0.7}{1.6}{0.6}{0.9}{0.8}{0.2}{0.1}{1.9}}
\QSoneStep
\QSoneStep
\QSoneStep
\QSoneStep
\QSoneStep
\endgroup

```

1.0	0.5	0.3	1.5	1.8	2.0	1.7	0.4	1.2	1.4	1.3	1.1	0.7	1.6	0.6	0.9	0.8	0.2	0.1	1.9
1.0	0.5	0.3	1.5	1.8	2.0	1.7	0.4	1.2	1.4	1.3	1.1	0.7	1.6	0.6	0.9	0.8	0.2	0.1	1.9
0.5	0.3	0.4	0.7	0.6	0.9	0.8	0.2	0.1	1.0	1.5	1.8	2.0	1.7	1.2	1.4	1.3	1.1	1.6	1.9
0.5	0.3	0.4	0.7	0.6	0.9	0.8	0.2	0.1	1.0	1.5	1.8	2.0	1.7	1.2	1.4	1.3	1.1	1.6	1.9
0.3	0.4	0.2	0.1	0.5	0.7	0.6	0.9	0.8	1.0	1.2	1.4	1.3	1.1	1.5	1.8	2.0	1.7	1.6	1.9
0.3	0.4	0.2	0.1	0.5	0.7	0.6	0.9	0.8	1.0	1.2	1.4	1.3	1.1	1.5	1.8	2.0	1.7	1.6	1.9
0.2	0.1	0.3	0.4	0.5	0.6	0.7	0.9	0.8	1.0	1.1	1.2	1.4	1.3	1.5	1.7	1.6	1.8	2.0	1.9
0.2	0.1	0.3	0.4	0.5	0.6	0.7	0.9	0.8	1.0	1.1	1.2	1.4	1.3	1.5	1.7	1.6	1.8	2.0	1.9
0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0
0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0
0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0

If one wants rather to have the pivot from the end of the yet to sort chunks, then one should use the following variants:

```

\def\QS@c #1{\expandafter\QS@e\expandafter
  {\romannumeral0\xintnthelt {-1}{#1}}{#1}%
}%
\def\DecoLEFTwithPivot #1{%
  \xintFor* ##1 in {#1} \do
  {\xintifForLast {\DecoPivot {##1}}{\colorbox{LEFT}{##1}}}%
}
\def\DecoRIGHTwithPivot #1{%
  \xintFor* ##1 in {#1} \do
  {\xintifForLast {\DecoPivot {##1}}{\colorbox{RIGHT}{##1}}}%
}
\def\QSinitialize #1{\def\QS@list{\QSLr {#1}}%
  \let\QSLr\DecoLEFT
%
  \QS@list \par
}

```

```
\par\centerline{\QS@list}
}
```

1.0	0.5	0.3	1.5	1.8	2.0	1.7	0.4	1.2	1.4	1.3	1.1	0.7	1.6	0.6	0.9	0.8	0.2	0.1	1.9
1.0	0.5	0.3	1.5	1.8	2.0	1.7	0.4	1.2	1.4	1.3	1.1	0.7	1.6	0.6	0.9	0.8	0.2	0.1	1.9
1.0	0.5	0.3	1.5	1.8	1.7	0.4	1.2	1.4	1.3	1.1	0.7	1.6	0.6	0.9	0.8	0.2	0.1	1.9	2.0
1.0	0.5	0.3	1.5	1.8	1.7	0.4	1.2	1.4	1.3	1.1	0.7	1.6	0.6	0.9	0.8	0.2	0.1	1.9	2.0
0.1	1.0	0.5	0.3	1.5	1.8	1.7	0.4	1.2	1.4	1.3	1.1	0.7	1.6	0.6	0.9	0.8	0.2	1.9	2.0
0.1	1.0	0.5	0.3	1.5	1.8	1.7	0.4	1.2	1.4	1.3	1.1	0.7	1.6	0.6	0.9	0.8	0.2	1.9	2.0
0.1	0.2	1.0	0.5	0.3	1.5	1.8	1.7	0.4	1.2	1.4	1.3	1.1	0.7	1.6	0.6	0.9	0.8	1.9	2.0
0.1	0.2	1.0	0.5	0.3	1.5	1.8	1.7	0.4	1.2	1.4	1.3	1.1	0.7	1.6	0.6	0.9	0.8	1.9	2.0
0.1	0.2	0.5	0.3	0.4	0.7	0.6	0.8	1.0	1.5	1.8	1.7	1.2	1.4	1.3	1.1	1.6	0.9	1.9	2.0
0.1	0.2	0.5	0.3	0.4	0.7	0.6	0.8	1.0	1.5	1.8	1.7	1.2	1.4	1.3	1.1	1.6	0.9	1.9	2.0
0.1	0.2	0.5	0.3	0.4	0.6	0.7	0.8	0.9	1.0	1.5	1.8	1.7	1.2	1.4	1.3	1.1	1.6	1.9	2.0
0.1	0.2	0.5	0.3	0.4	0.6	0.7	0.8	0.9	1.0	1.5	1.8	1.7	1.2	1.4	1.3	1.1	1.6	1.9	2.0
0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.5	1.2	1.4	1.3	1.1	1.6	1.8	1.7	1.9	2.0
0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.5	1.2	1.4	1.3	1.1	1.6	1.8	1.7	1.9	2.0
0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.5	1.2	1.4	1.3	1.6	1.7	1.8	1.9	2.0
0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.5	1.2	1.4	1.3	1.6	1.7	1.8	1.9	2.0
0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.5	1.4	1.6	1.7	1.8	1.9	2.0
0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0
0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0
0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0

It is possible to modify this code to let it do `\QSonestep` repeatedly and stop automatically when the sort is finished.<sup>53</sup>

## 28 Commands of the **xint** package

In the description of the macros `{N}` and `{M}` stand for (long) numbers within braces or for a control sequence possibly within braces and *f*-expanding to such a number (without the braces!), or for material within braces which *f*-expands to such a number, as is acceptable on input by the `\xintNum` macro: a sequence of plus and minus signs, followed by some string of zeros, followed by digits. The margin annotation for such an argument which is parsed by `\xintNum` is  $\overset{\text{Num}}{f}$ . Sometimes however only a *f* symbol appears in the margin, signaling that the input will not be parsed via `\xintNum`.

The letter *x* (with margin annotation  $\overset{\text{num}}{x}$ ) stands for something which will be inserted in-between a `\numexpr` and a `\relax`. It will thus be completely expanded and must give an integer obeying the  $\text{\TeX}$  bounds. Thus, it may be for example a count register, or itself a `\numexpr` expression, or just a number written explicitly with digits or something like `4*\count 255 + 17`, etc...

For the rules regarding direct use of count registers or `\numexpr` expression, in the argument to the package macros, see the [Use of count](#) section.

Some of these macros are extended by **xintfrac** to accept fractions on input, and, generally, to output a fraction. But this means that additions, subtractions, multiplications output in fraction format; to guarantee the integer format on output when the inputs are

<sup>53</sup> <http://tex.stackexchange.com/a/142634/4686>

integers, the original integer-only macros `\xintAdd`, `\xintSub`, `\xintMul`, etc... are available under the names `\xintiAdd`, `\xintiSub`, `\xintiMul`, ..., also when **xintfrac** is not loaded. Even these originally integer-only macros will accept fractions on input if **xintfrac** is loaded as long as they are integers in disguise; they produce on output integers without any forward slash mark nor trailing [n].

But `\xintAdd` will output fractions  $A/B[n]$ , with  $B$  present even if its value is one. See the **xintfrac** [documentation](#) for additional information.

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### 28.1 `\xintRev`

*f*★ `\xintRev{N}` will revert the order of the digits of the number, keeping the optional sign.

Leading zeros resulting from the operation are not removed (see the `\xintNum` macro for this). This macro and all other macros dealing with numbers first expand ‘fully’ their arguments.

```
\xintRev{-123000}=-000321
\xintNum{\xintRev{-123000}}=-321
```

## 28.2 `\xintLen`

*Num*  
*f* ★

`\xintLen{N}` returns the length of the number, not counting the sign.

```
\xintLen{-12345678901234567890123456789}=29
```

Extended by **xintfrac** to fractions: the length of  $A/B[n]$  is the length of  $A$  plus the length of  $B$  plus the absolute value of  $n$  and minus one (an integer input as  $N$  is internally represented in a form equivalent to  $N/1[0]$  so the minus one means that the extended `\xintLen` behaves the same as the original for integers).

```
\xintLen{-1e3/5.425}=10
```

The length is computed on the  $A/B[n]$  which would have been returned by `\xintRaw`:  
`\xintRaw {-1e3/5.425}=-1/5425[6]`.

Let’s point out that the whole thing should sum up to less than circa  $2^{\{31\}}$ , but this is a bit theoretical.

`\xintLen` is only for numbers or fractions. See `\xintLength` for counting tokens (or rather braced groups), more generally.

## 28.3 `\xintDigitsOf`

*fN*

This is a synonym for `\xintAssignArray`, to be used to define an array giving all the digits of a given (positive, else the minus sign will be treated as first item) number.

```
\xintDigitsOf\xintiPow {7}{500}\to\digits
```

$7^{500}$  has `\digits{0}=423` digits, and the 123rd among them (starting from the most significant) is `\digits{123}=3`.

## 28.4 `\xintNum`

*f* ★

`\xintNum{N}` removes chains of plus or minus signs, followed by zeros.

```
\xintNum{+---+-----+--000000000367941789479}=-367941789479
```

Extended by **xintfrac** to accept also a fraction on input, as long as it reduces to an integer after division of the numerator by the denominator.

```
\xintNum{123.48/-0.03}=-4116
```

## 28.5 `\xintSgn`

*Num*  
*f* ★

`\xintSgn{N}` returns 1 if the number is positive, 0 if it is zero and -1 if it is negative.

*f* ★

Extended by **xintfrac** to fractions. `\xintiiSgn` skips the `\xintNum` overhead.

## 28.6 `\xintOpp`

*Num*  
*f* ★

`\xintOpp{N}` return the opposite  $-N$  of the number  $N$ . Extended by **xintfrac** to fractions.

$f$  ★ `\xintiOpp` is a synonym not modified by **xintfrac**<sup>54</sup>, and `\xintiiOpp` skips the `\xint-`  
`Num` overhead.

## 28.7 `\xintAbs`

$f$  ★ `\xintAbs{N}` returns the absolute value of the number. Extended by **xintfrac** to fractions. `\xintiAbs` is a synonym not modified by **xintfrac**, and `\xintiiAbs` skips the  
 $f$  ★ `\xintNum` overhead.

## 28.8 `\xintAdd`

$f$  ★ `\xintAdd{N}{M}` returns the sum of the two numbers. Extended by **xintfrac** to fractions. `\xintiAdd` is a synonym not modified by **xintfrac**, and `\xintiiAdd` skips the `\xintNum`  
 $ff$  ★ overhead.

## 28.9 `\xintSub`

$f$  ★ `\xintSub{N}{M}` returns the difference  $N-M$ . Extended by **xintfrac** to fractions. `\xintiSub` is a synonym not modified by **xintfrac**, and `\xintiiSub` skips the `\xintNum`  
 $ff$  ★ overhead.

## 28.10 `\xintCmp`

$f$  ★ `\xintCmp{N}{M}` returns 1 if  $N>M$ , 0 if  $N=M$ , and -1 if  $N<M$ . Extended by **xintfrac** to fractions.

## 28.11 `\xintEq`

$f$  ★ `\xintEq{N}{M}` returns 1 if  $N=M$ , 0 otherwise. Extended by **xintfrac** to fractions.

## 28.12 `\xintGt`

$f$  ★ `\xintGt{N}{M}` returns 1 if  $N>M$ , 0 otherwise. Extended by **xintfrac** to fractions.

## 28.13 `\xintLt`

$f$  ★ `\xintLt{N}{M}` returns 1 if  $N<M$ , 0 otherwise. Extended by **xintfrac** to fractions.

## 28.14 `\xintIsZero`

$f$  ★ `\xintIsZero{N}` returns 1 if  $N=0$ , 0 otherwise. Extended by **xintfrac** to fractions.

## 28.15 `\xintNot`

$f$  ★ `\xintNot` is a synonym for `\xintIsZero`.

## 28.16 `\xintIsNotZero`

$f$  ★ `\xintIsNotZero{N}` returns 1 if  $N\neq 0$ , 0 otherwise. Extended by **xintfrac** to fractions.

---

<sup>54</sup> here, and in all similar instances, this means that the macro remains integer-only both on input and output, but it does accept on input a fraction which in disguise is a (big) integer.

**28.17 \xintIsOne**

$\overset{\text{Num}}{f} \star$   $\backslash\text{xintIsOne}\{N\}$  returns 1 if  $N=1$ , 0 otherwise. Extended by **xintfrac** to fractions.

**28.18 \xintAND**

$\overset{\text{Num}}{f} \overset{\text{Num}}{f} \star$   $\backslash\text{xintAND}\{N\}\{M\}$  returns 1 if  $N \neq 0$  and  $M \neq 0$  and zero otherwise. Extended by **xintfrac** to fractions.

**28.19 \xintOR**

$\overset{\text{Num}}{f} \overset{\text{Num}}{f} \star$   $\backslash\text{xintOR}\{N\}\{M\}$  returns 1 if  $N \neq 0$  or  $M \neq 0$  and zero otherwise. Extended by **xintfrac** to fractions.

**28.20 \xintXOR**

$\overset{\text{Num}}{f} \overset{\text{Num}}{f} \star$   $\backslash\text{xintXOR}\{N\}\{M\}$  returns 1 if exactly one of  $N$  or  $M$  is true (i.e. non-zero). Extended by **xintfrac** to fractions.

**28.21 \xintANDof**

$f \rightarrow * \overset{\text{Num}}{f} \star$   $\backslash\text{xintANDof}\{\{a\}\{b\}\{c\}\dots\}$  returns 1 if all are true (i.e. non zero) and zero otherwise. The list argument may be a macro, it (or rather its first token) is  $f$ -expanded first (each item also is  $f$ -expanded). Extended by **xintfrac** to fractions.

**28.22 \xintORof**

$f \rightarrow * \overset{\text{Num}}{f} \star$   $\backslash\text{xintORof}\{\{a\}\{b\}\{c\}\dots\}$  returns 1 if at least one is true (i.e. does not vanish). The list argument may be a macro, it is  $f$ -expanded first. Extended by **xintfrac** to fractions.

**28.23 \xintXORof**

$f \rightarrow * \overset{\text{Num}}{f} \star$   $\backslash\text{xintXORof}\{\{a\}\{b\}\{c\}\dots\}$  returns 1 if an odd number of them are true (i.e. does not vanish). The list argument may be a macro, it is  $f$ -expanded first. Extended by **xintfrac** to fractions.

**28.24 \xintGeq**

$\overset{\text{Num}}{f} \overset{\text{Num}}{f} \star$   $\backslash\text{xintGeq}\{N\}\{M\}$  returns 1 if the *absolute value* of the first number is at least equal to the absolute value of the second number. If  $|N| < |M|$  it returns 0. Extended by **xintfrac** to fractions. Please note that the macro compares *absolute values*.

**28.25 \xintMax**

$\overset{\text{Num}}{f} \overset{\text{Num}}{f} \star$   $\backslash\text{xintMax}\{N\}\{M\}$  returns the largest of the two in the sense of the order structure on the relative integers (i.e. the right-most number if they are put on a line with positive numbers on the right):  $\backslash\text{xintiMax}\{-5\}\{-6\}=-5$ . Extended by **xintfrac** to fractions.  $\backslash\text{xintiMax}$  is a synonym not modified by **xintfrac**.

**28.26 \xintMaxof**

$f \rightarrow *$   $\overset{\text{Num}}{f}$  ★ `\xintMaxof{a}{b}{c}...` returns the maximum. The list argument may be a macro, it is *f*-expanded first. Extended by **xintfrac** to fractions. `\xintiMaxof` is a synonym not modified by **xintfrac**.

**28.27 \xintMin**

$\overset{\text{Num}}{f}$   $\overset{\text{Num}}{f}$  ★ `\xintMin{N}{M}` returns the smallest of the two in the sense of the order structure on the relative integers (*i.e.* the left-most number if they are put on a line with positive numbers on the right): `\xintiMin {-5}{-6}=-6`. Extended by **xintfrac** to fractions. `\xintiMin` is a synonym not modified by **xintfrac**.

**28.28 \xintMinof**

$f \rightarrow *$   $\overset{\text{Num}}{f}$  ★ `\xintMinof{a}{b}{c}...` returns the minimum. The list argument may be a macro, it is *f*-expanded first. Extended by **xintfrac** to fractions. `\xintiMinof` is a synonym not modified by **xintfrac**.

**28.29 \xintSum**

$*f$  ★ `\xintSum{<braced things>}` after expanding its argument expects to find a sequence of tokens (or braced material). Each is expanded (with the usual meaning), and the sum of all these numbers is returned. Note: the summands are *not* parsed by `\xintNum`.

`\xintSum` is extended by **xintfrac** to fractions. The original, which accepts (after *f*-expansion) only (big) integers in the strict format and produces a (big) integer is available as `\xintiiSum`, also with **xintfrac** loaded.

`\xintiiSum{123}{-98763450}{\xintFac{7}}{\xintiMul{3347}{591}}=-96780210`  
`\xintiiSum{1234567890}=45`

An empty sum is no error and returns zero: `\xintiiSum {}=0`. A sum with only one term returns that number: `\xintiiSum {-1234}=-1234`. Attention that `\xintiiSum {-1234}` is not legal input and will make the  $\text{\TeX}$  run fail. On the other hand `\xintiiSum {1234}=10`. Extended by **xintfrac** to fractions.

**28.30 \xintMul**

$\overset{\text{Num}}{f}$   $\overset{\text{Num}}{f}$  ★ `\xintMul{N}{M}` returns the product of the two numbers. Extended by **xintfrac** to fractions. `\xintiMul` is a synonym not modified by **xintfrac**, and `\xintiiMul` skips the  $ff$  ★ `\xintNum` overhead.

**28.31 \xintSqr**

$\overset{\text{Num}}{f}$  ★ `\xintSqr{N}` returns the square. Extended by **xintfrac** to fractions. `\xintiSqr` is a synonym not modified by **xintfrac**, and `\xintiiSqr` skips the `\xintNum` overhead.

**28.32 \xintPrd**

$*f$  ★ `\xintPrd{<braced things>}` after expanding its argument expects to find a sequence of (of braced items or unbraced single tokens). Each is expanded (with the usual meaning), and

the product of all these numbers is returned. Note: the operands are *not* parsed by `\xintNum`.

```
\xintiiPrd{-9876}{\xintFac{7}}{\xintiMul{3347}{591}}=-98458861798080
\xintiiPrd{123456789123456789}=131681894400
```

An empty product is no error and returns 1: `\xintiiPrd {}=1`. A product reduced to a single term returns this number: `\xintiiPrd {-1234}=-1234`. Attention that `\xintiPrd {-1234}` is not legal input and will make the  $\text{\TeX}$  compilation fail. On the other hand `\xintiiPrd {1234}=24`.

$$2^{200}3^{100}7^{100}$$

```
=\xintiiPrd {\xintiPow {2}{200}}{\xintiPow {3}{100}}{\xintiPow {7}{100}}
=26787279316615775757662795170075484023247402663740153489744596148
154264129654994900004440072407657271300001653120764065456211801435
71994015903343539244028212438966822248927862988084382716133376 With
xintexpr, the above would be coded simply as
```

```
\xinttheiexpr 2^200*3^100*7^100\relax
```

Extended by **xintfrac** to fractions. The original, which accepts (after *f*-expansion) only (big) integers in the strict format and produces a (big) integer is available as `\xintiiPrd`, also with **xintfrac** loaded.

### 28.33 `\xintPow`

$\overset{\text{Num}}{f} \overset{\text{num}}{x} \star$  **Changed!**  $\rightarrow$  `\xintPow{N}{x}` returns  $N^x$ . When  $x$  is zero, this is 1. If  $N$  is zero and  $x < 0$ , if  $|N| > 1$  and  $x < 0$  negative, or if  $|N| > 1$  and  $x > 100000$ , then an error is raised. Indeed  $2^{50000}$  already has 15052 digits; each exact multiplication of two one thousand digits numbers already takes a few seconds, and it would take hours for the expandable computation to conclude with two numbers with each circa 15000 digits. Perhaps some completely expandable but not *f*-expandable variants could fare better?

Extended by **xintfrac** to fractions (`\xintPow`) and to floats (`\xintFloatPow`). Negative exponents do not then cause errors anymore. The float version is able to deal with things such as  $2^{999999999}$  without any problem. For example `\xintFloatPow[4]{2}{50000}=3.161e15051` and `\xintFloatPow[4]{2}{999999999}=2.306e301029995`.<sup>55</sup>

$\overset{f}{f} \overset{\text{num}}{x} \star$  `\xintiPow` is a synonym not modified by **xintfrac**, and `\xintiiPow` is an integer only variant skipping the `\xintNum` overhead, it produces the same result as `\xintiPow` with stricter assumptions on the inputs, and is thus a tiny bit faster. Within an `\xintiiexpr... \relax` the infix operator `^` is mapped to `\xintiiPow` (in **xintexpr**, the **xintfrac** routine `\xintFloatPower` is used instead.)

### 28.34 `\xintSgnFork`

$xnnn \star$  `\xintSgnFork{-1|0|1}{\langle A \rangle}{\langle B \rangle}{\langle C \rangle}` expandably chooses to execute either the  $\langle A \rangle$ ,  $\langle B \rangle$  or  $\langle C \rangle$  code, depending on its first argument. This first argument should be anything expanding to either -1, 0 or 1 (a count register must be prefixed by `\the` and a `\numexpr... \relax` also must be prefixed by `\the`). This utility is provided to help construct

<sup>55</sup> On my laptop `\xintiiPow{2}{9999}` obtains all 3010 digits in about ten or eleven seconds. In contrast, the float versions for 8, 16, 24, or even more significant figures, do their jobs in less than one hundredth of a second (1.09j; we used in the text only four significant digits only for reasons of space, not time.) This is done without `log/exp` which are not (yet?) implemented in **xintfrac**. The  $\text{\LaTeX}$  3 `l3fp` does this with `log/exp` and is ten times faster (16 figures only).

expandable macros choosing depending on a condition which one of the package macros to use, or which values to confer to their arguments.

### 28.35 **\xintifSgn**

$\text{Num}$   
 $f$   $nn$  ★ Similar to `\xintSgnFork` except that the first argument may expand to a (big) integer (or a fraction if **xintfrac** is loaded), and it is its sign which decides which of the three branches is taken. Furthermore this first argument may be a count register, with no `\the` or `\number` prefix.

### 28.36 **\xintifZero**

$\text{Num}$   
 $f$   $nn$  ★ `\xintifZero{<N>}{<IsZero>}{<IsNotZero>}` expandably checks if the first mandatory argument N (a number, possibly a fraction if **xintfrac** is loaded, or a macro expanding to one such) is zero or not. It then either executes the first or the second branch. Beware that both branches must be present.

### 28.37 **\xintifNotZero**

$\text{Num}$   
 $f$   $nn$  ★ `\xintifNotZero{<N>}{<IsNotZero>}{<IsZero>}` expandably checks if the first mandatory argument N (a number, possibly a fraction if **xintfrac** is loaded, or a macro expanding to one such) is not zero or is zero. It then either executes the first or the second branch. Beware that both branches must be present.

### 28.38 **\xintifOne**

$\text{Num}$   
 $f$   $nn$  ★ `\xintifOne{<N>}{<IsOne>}{<IsNotOne>}` expandably checks if the first mandatory argument N (a number, possibly a fraction if **xintfrac** is loaded, or a macro expanding to one such) is one or not. It then either executes the first or the second branch. Beware that both branches must be present.

### 28.39 **\xintifTrueAelseB, \xintifFalseAelseB**

$\text{Num}$   
 $f$   $nn$  ★ `\xintifTrueAelseB{<N>}{<true branch>}{<false branch>}` is a synonym for `\xintifNotZero`.

1. with 1.09i, the synonyms `\xintifTrueFalse` and `\xintifTrue` are deprecated and will be removed in next release.

2. These macros have no lowercase versions, use `\xintifzero`, `\xintifnotzero`.

$\text{Num}$   
 $f$   $nn$  ★ `\xintifFalseAelseB{<N>}{<false branch>}{<true branch>}` is a synonym for `\xintifZero`.

### 28.40 **\xintifCmp**

$\text{Num Num}$   
 $f f$   $nnn$  ★ `\xintifCmp{<A>}{<B>}{<if A<B>}{<if A=B>}{<if A>B>}` compares its arguments and chooses accordingly the correct branch.

**28.41 \xintifEq**

$\text{Num Num}$   
 $\text{f f nn} \star$  `\xintifEq{<A>}{<B>}{<YES>}{<NO>}` checks equality of its two first arguments (numbers, or fractions if **xintfrac** is loaded) and does the YES or the NO branch.

**28.42 \xintifGt**

$\text{Num Num}$   
 $\text{f f nn} \star$  `\xintifGt{<A>}{<B>}{<YES>}{<NO>}` checks if  $A > B$  and in that case executes the YES branch. Extended to fractions (in particular decimal numbers) by **xintfrac**.

**28.43 \xintifLt**

$\text{Num Num}$   
 $\text{f f nn} \star$  `\xintifLt{<A>}{<B>}{<YES>}{<NO>}` checks if  $A < B$  and in that case executes the YES branch. Extended to fractions (in particular decimal numbers) by **xintfrac**.

The macros described next are all integer-only on input. With **xintfrac** loaded their argument is first given to `\xintNum` and may thus be a fraction, as long as it is in fact an integer in disguise.

**28.44 \xintifOdd**

$\text{Num}$   
 $\text{f nn} \star$  `\xintifOdd{<A>}{<YES>}{<NO>}` checks if  $A$  is an odd integer and in that case executes the YES branch.

**28.45 \xintFac**

$\text{num}$   
 $\text{x} \star$  `\xintFac{x}` returns the factorial. It is an error if the argument is negative or at least  $10^5$ .  
With **xintfrac** loaded, the macro is modified to accept a fraction as argument, as long as this fraction turns out to be an integer: `\xintFac {66/3}=1124000727777607680000`.  
`\xintiFac` is a synonym not modified by the loading of **xintfrac**.

**28.46 \xintDivision**

$\text{Num Num}$   
 $\text{f f} \star$  `\xintDivision{N}{M}` returns {quotient Q}{remainder R}. This is euclidean division:  $N = QM + R$ ,  $0 \leq R < |M|$ . So the remainder is always non-negative and the formula  $N = QM + R$  always holds independently of the signs of  $N$  or  $M$ . Division by zero is an error (even if  $N$  vanishes) and returns `{0}{0}`. The variant `\xintiiDivision` skips the overhead of parsing via `\xintNum`.

This macro is integer only (with **xintfrac** loaded it accepts fractions on input, but they must be integers in disguise) and not to be confused with the **xintfrac** macro `\xintDiv` which divides one fraction by another.

**28.47 \xintQuo**

$\text{Num Num}$   
 $\text{f f} \star$  `\xintQuo{N}{M}` returns the quotient from the euclidean division. When both  $N$  and  $M$  are positive one has `\xintQuo{N}{M}=\xintiTrunc {0}{N/M}` (using package **xintfrac**).  
With **xintfrac** loaded it accepts fractions on input, but they must be integers in disguise.  
 $\text{ff} \star$  The variant `\xintiiQuo` skips the overhead of parsing via `\xintNum`.

## 28.48 \xintRem

$\frac{\text{Num}}{f} \frac{\text{Num}}{f} \star$  `\xintRem{N}{M}` returns the remainder from the euclidean division. With `\xintfrac` loaded it accepts fractions on input, but they must be integers in disguise. The variant  $ff \star$  `\xintiiRem` skips the overhead of parsing via `\xintNum`.

## 28.49 \xintFDg

$\text{Num}_f$	★	<code>\xintFDg{N}</code> returns the first digit (most significant) of the decimal expansion. The variant
$f$	★	<code>\xintiifDg</code> skips the overhead of parsing via <code>\xintNum</code> .

**28.50** \xintLDq

**Num**  
*f* ★ `\xintLDg{N}` returns the least significant digit. When the number is positive, this is the same as the remainder in the euclidean division by ten. The variant `\xintiLDg` skips the overhead of parsing via `\xintNum`.

## 28.51 \xintMON, \xintMMON

**Num**  
**f** ★ `\xintMON{N}` returns  $(-1)^N$  and `\xintMMON{N}` returns  $(-1)^{N-1}$ .  
`\xintMON {-280914019374101929}=-1`, `\xintMMON {-280914019374101929}=1`  
**f** ★ The variants `\xintiMON` and `\xintiMMON` skip the overhead of parsing via `\xintNum`.

**28.52** \xintOdd

Num  
f ★ \xintOdd{N} is 1 if the number is odd and 0 otherwise. The variant \xintiiOdd skip the  
f ★ overhead of parsing via \xintNum.

### 28.53 \xintiSqrt, \xintiSquareRoot

**Num**  
*f*

★ \xintiSqrt{N} returns the largest integer whose square is at most equal to N.

\xintiSqrt {200000000000000000000000000000000}=1414213562373095048

\xintiSqrt {300000000000000000000000000000000}=1732050807568877293

\xintiSqrt {\xintDSH {-120}{2}}=

1414213562373095048801688724209698078569671875376948073176679

**Num**  
*f*

★ \xintiSquareRoot{N} returns {M}-{d} with d>0, M^2-d=N and M smallest (hence =1+\xintiSqrt{N}).

\xintAssign\xintiSquareRoot {1700000000000000000000000}\to\A\B

\xintiSub{\xintisqr\A}\B=\A^2-\B

17000000000000000000000000=4123105625618~2-2799177881924

A rational approximation to  $\sqrt{N}$  is  $M - \frac{d}{2M}$  (this is a majorant and the error is at most  $1/(2M)$ ; if N is a perfect square  $k^2$  then  $M=k+1$  and this gives  $k+1/(2k+2)$ , not k).

Package **xintfrac** has **\xintFloatSqrt** for square roots of floating point numbers.

The macros described next are strictly for integer-only arguments. These arguments are *not* filtered via `\xintNum`.

### 28.54 **\xintInc**, **\xintDec**

*f* ★ **\xintInc**{N} is N+1 and **\xintDec**{N} is N-1. These macros remain integer-only, even with **xintfrac** loaded.

### 28.55 **\xintDouble**, **\xintHalf**

*f* ★ **\xintDouble**{N} returns 2N and **\xintHalf**{N} is N/2 rounded towards zero. These macros remain integer-only, even with **xintfrac** loaded.

### 28.56 **\xintDSL**

*f* ★ **\xintDSL**{N} is decimal shift left, *i.e.* multiplication by ten.

### 28.57 **\xintDSR**

*f* ★ **\xintDSR**{N} is decimal shift right, *i.e.* it removes the last digit (keeping the sign), equivalently it is the closest integer to N/10 when starting at zero.

### 28.58 **\xintDSH**

<sup>num</sup><sub>x</sub> *f* ★ **\xintDSH**{x}{N} is parametrized decimal shift. When x is negative, it is like iterating **\xintDSL** |x| times (*i.e.* multiplication by  $10^{-x}$ ). When x positive, it is like iterating **\DSR** x times (and is more efficient), and for a non-negative N this is thus the same as the quotient from the euclidean division by  $10^x$ .

### 28.59 **\xintDSHr**, **\xintDSx**

<sup>num</sup><sub>x</sub> *f* ★ **\xintDSHr**{x}{N} expects x to be zero or positive and it returns then a value R which is correlated to the value Q returned by **\xintDSH**{x}{N} in the following manner:

- if N is positive or zero, Q and R are the quotient and remainder in the euclidean division by  $10^x$  (obtained in a more efficient manner than using **\xintDivision**),
- if N is negative let Q1 and R1 be the quotient and remainder in the euclidean division by  $10^x$  of the absolute value of N. If Q1 does not vanish, then  $Q=-Q1$  and  $R=R1$ . If Q1 vanishes, then  $Q=0$  and  $R=-R1$ .
- for  $x=0$ ,  $Q=N$  and  $R=0$ .

So one has  $N = 10^x Q + R$  if Q turns out to be zero or positive, and  $N = 10^x Q - R$  if Q turns out to be negative, which is exactly the case when N is at most  $-10^x$ .

<sup>num</sup><sub>x</sub> *f* ★ **\xintDSx**{x}{N} for x negative is exactly as **\xintDSH**{x}{N}, *i.e.* multiplication by  $10^{-x}$ . For x zero or positive it returns the two numbers {Q}{R} described above, each one within braces. So Q is **\xintDSH**{x}{N}, and R is **\xintDSHr**{x}{N}, but computed simultaneously.

```
\xintAssign\xintDSx {-1}{-123456789}\to\M
\meaning\M: macro:->-1234567890.
\xintAssign\xintDSx {-20}{123456789}\to\M
```

```

\meaning\M: macro:->123456768900000000000000000000.
\xintAssign\xintDSx {0}{-123004321}\to\Q\R
\meaning\Q: macro:->-123004321, \meaning\R: macro:->0.
\xintDSH {0}{-123004321}=-123004321, \xintDSHr {0}{-123004321}=0
\xintAssign\xintDSx {6}{-123004321}\to\Q\R
\meaning\Q: macro:->-123, \meaning\R: macro:->4321.
\xintDSH {6}{-123004321}=-123, \xintDSHr {6}{-123004321}=4321
\xintAssign\xintDSx {8}{-123004321}\to\Q\R
\meaning\Q: macro:->-1, \meaning\R: macro:->23004321.
\xintDSH {8}{-123004321}=-1, \xintDSHr {8}{-123004321}=23004321
\xintAssign\xintDSx {9}{-123004321}\to\Q\R
\meaning\Q: macro:->0, \meaning\R: macro:->-123004321.
\xintDSH {9}{-123004321}=0, \xintDSHr {9}{-123004321}=-123004321

```

## 28.60 \xintDecSplit

$\overset{\text{num}}{x} f \star$  \xintDecSplit{x}{N} cuts the number into two pieces (each one within a pair of enclosing braces). First the sign if present is *removed*. Then, for x positive or null, the second piece contains the x least significant digits (*empty* if x=0) and the first piece the remaining digits (*empty* when x equals or exceeds the length of N). Leading zeros in the second piece are not removed. When x is negative the first piece contains the |x| most significant digits and the second piece the remaining digits (*empty* if |x| equals or exceeds the length of N). Leading zeros in this second piece are not removed. So the absolute value of the original number is always the concatenation of the first and second piece.

This macro's behavior for N non-negative is final and will not change. I am still hesitant about what to do with the sign of a negative N.

```

\xintAssign\xintDecSplit {0}{-123004321}\to\L\R
\meaning\L: macro:->123004321, \meaning\R: macro:->.
\xintAssign\xintDecSplit {5}{-123004321}\to\L\R
\meaning\L: macro:->1230, \meaning\R: macro:->04321.
\xintAssign\xintDecSplit {9}{-123004321}\to\L\R
\meaning\L: macro:->, \meaning\R: macro:->123004321.
\xintAssign\xintDecSplit {10}{-123004321}\to\L\R
\meaning\L: macro:->, \meaning\R: macro:->123004321.
\xintAssign\xintDecSplit {-5}{-12300004321}\to\L\R
\meaning\L: macro:->12300, \meaning\R: macro:->004321.
\xintAssign\xintDecSplit {-11}{-12300004321}\to\L\R
\meaning\L: macro:->12300004321, \meaning\R: macro:->.
\xintAssign\xintDecSplit {-15}{-12300004321}\to\L\R
\meaning\L: macro:->12300004321, \meaning\R: macro:->.

```

## 28.61 \xintDecSplitL

$\overset{\text{num}}{x} f \star$  \xintDecSplitL{x}{N} returns the first piece after the action of \xintDecSplit.

## 28.62 \xintDecSplitR

$\overset{\text{num}}{x} f \star$  \xintDecSplitR{x}{N} returns the second piece after the action of \xintDecSplit.

## 29 Commands of the **xintfrac** package

This package was first included in release 1.03 of the **xint** bundle. The general rule of the bundle that each macro first expands (what comes first, fully) each one of its arguments applies.

**Frac**  
*f*

*f* stands for an integer or a fraction (see [section 9](#) for the accepted input formats) or something which expands to an integer or fraction. It is possible to use in the numerator or the denominator of *f* count registers and even expressions with infix arithmetic operators, under some rules which are explained in the previous [Use of count registers](#) section.

**num**  
*x*

As in the [xint.sty](#) documentation, *x* stands for something which will internally be embedded in a `\numexpr`. It may thus be a count register or something like `4*\count 255 + 17`, etc..., but must expand to an integer obeying the  $\TeX$  bound.

The fraction format on output is the scientific notation for the ‘float’ macros, and the `A/B[n]` format for all other fraction macros, with the exception of `\xintTrunc`, `\xintRound` (which produce decimal numbers) and `\xintIrr`, `\xintJrr`, `\xintRawWithZeros` (which returns an `A/B` with no trailing `[n]`, and prints the `B` even if it is 1), and `\xintPraw` which does not print the `[n]` if `n=0` or the `B` if `B=1`.

To be certain to print an integer output without trailing `[n]` nor fraction slash, one should use either `\xintPraw {\xintIrr {f}}` or `\xintNum {f}` when it is already known that *f* evaluates to a (big) integer. For example `\xintPraw {\xintAdd {2/5}{3/5}}` gives a perhaps disappointing `25/25`<sup>56</sup>, whereas `\xintPraw {\xintIrr {\xintAdd {2/5}{3/5}}}` returns 1. As we knew the result was an integer we could have used `\xintNum {\xintAdd {2/5}{3/5}}`=1.

Some macros (such as `\xintiTrunc`, `\xintiRound`, and `\xintFac`) always produce directly integers on output.

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<sup>56</sup> yes, `\xintAdd` blindly multiplies denominators...

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### 29.1 `\xintNum`

- $\frac{f}{f}$  ★ The macro is extended to accept a fraction on input. But this fraction should reduce to an integer. If not an error will be raised. The original is available as `\xintiNum`. It is imprudent to apply `\xintNum` to numbers with a large power of ten given either in scientific notation or with the `[n]` notation, as the macro will add the necessary zeros to get an explicit integer.

### 29.2 `\xintifInt`

- $\frac{\text{Frac}}{f}$   $\frac{nn}{nn}$  ★ `\xintifInt{f}{YES branch}{NO branch}` expandably chooses the YES branch if `f` reveals itself after expansion and simplification to be an integer. As with the other **xint** conditionals, both branches must be present although one of the two (or both, but why then?) may well be an empty brace pair `{}`. As will all other **xint** conditionals, spaces in-between the braced things do not matter, but a space after the closing brace of the NO branch is significant.

### 29.3 `\xintLen`

- $\frac{\text{Frac}}{f}$  ★ The original macro is extended to accept a fraction on input.  
`\xintLen {201710/298219}=11, \xintLen {1234/1}=4, \xintLen {1234}=4`

### 29.4 `\xintRaw`

- $\frac{\text{Frac}}{f}$  ★ This macro ‘prints’ the fraction `f` as it is received by the package after its parsing and expansion, in a form `A/B[n]` equivalent to the internal representation: the denominator `B` is always strictly positive and is printed even if it has value 1.  
`\xintRaw{\the\numexpr 571*987\relax.123e-10/\the\numexpr -201+59\relax e-7}=-563577123/142[-6]`

### 29.5 `\xintPraw`

- $\frac{\text{Frac}}{f}$  ★ `Praw` stands for “pretty raw”. It does *not* show the `[n]` if `n=0` and does *not* show the `B` if `B=1`.  
`\xintPraw {123e10/321e10}=123/321, \xintPraw {123e9/321e10}=123/321[-1]`  
`\xintPraw {\xintIrr{861/123}}=7 vz. \xintIrr{861/123}=7/1`

See also `\xintFrac` (or `\xintFwOver`) for math mode. As is exemplified above the `\xintIrr` macro which puts the fraction into irreducible form does not remove the /1 if the fraction is an integer. One can use `\xintNum` for that, but there will be an error message if the fraction was not an integer; so the combination `\xintPraw{\xintIrr{f}}` is the way to go.

## 29.6 `\xintNumerator`

$\frac{\text{Frac}}{f}$  ★ This returns the numerator corresponding to the internal representation of a fraction, with positive powers of ten converted into zeros of this numerator:

```
\xintNumerator {178000/25600000[17]}=1780000000000000000000
\xintNumerator {312.289001/20198.27}=312289001
\xintNumerator {178000e-3/256e5}=178000
\xintNumerator {178.000/25600000}=178000
```

As shown by the examples, no simplification of the input is done. For a result uniquely associated to the value of the fraction first apply `\xintIrr`.

## 29.7 `\xintDenominator`

$\frac{\text{Frac}}{f}$  ★ This returns the denominator corresponding to the internal representation of the fraction:<sup>57</sup>

```
\xintDenominator {178000/25600000[17]}=25600000
\xintDenominator {312.289001/20198.27}=20198270000
\xintDenominator {178000e-3/256e5}=25600000000
\xintDenominator {178.000/25600000}=25600000000
```

As shown by the examples, no simplification of the input is done. The denominator looks wrong in the last example, but the numerator was tacitly multiplied by 1000 through the removal of the decimal point. For a result uniquely associated to the value of the fraction first apply `\xintIrr`.

## 29.8 `\xintRawWithZeros`

$\frac{\text{Frac}}{f}$  ★ This macro ‘prints’ the fraction *f* (after its parsing and expansion) in A/B form, with A as returned by `\xintNumerator{f}` and B as returned by `\xintDenominator{f}`.

```
\xintRawWithZeros{\the\numexpr 571*987\relax.123e-10/\the\numexpr -201+59\relax e-7}=-
-563577123/142000000
```

## 29.9 `\xintREZ`

$\frac{\text{Frac}}{f}$  ★ This command normalizes a fraction by removing the powers of ten from its numerator and denominator:

```
\xintREZ {178000/25600000[17]}=178/256[15]
\xintREZ {17800000000000e30/2560000000000e15}=178/256[15]
```

As shown by the example, it does not otherwise simplify the fraction.

<sup>57</sup> recall that the [] construct excludes presence of a decimal point.

**29.10 \xintFrac**

$\frac{\text{Frac}}{f}$  ★ This is a L<sup>A</sup>T<sub>E</sub>X only command, to be used in math mode only. It will print a fraction, internally represented as something equivalent to  $A/B[n]$  as `\frac {A}{B}10^n`. The power of ten is omitted when  $n=0$ , the denominator is omitted when it has value one, the number being separated from the power of ten by a `\cdot`. `\xintFrac {178.000/256000000}` gives  $\frac{178000}{256000000}10^{-3}$ , `\xintFrac {178.000/1}` gives  $178000 \cdot 10^{-3}$ , `\xintFrac {3.5/5.7}` gives  $\frac{35}{57}$ , and `\xintFrac {\xintNum {\xintFac{10}}/\xintiSqr{\xintFac {5}}}` gives 252. As shown by the examples, simplification of the input (apart from removing the decimal points and moving the minus sign to the numerator) is not done automatically and must be the result of macros such as `\xintIrr`, `\xintREZ`, or `\xintNum` (for fractions being in fact integers.)

**29.11 \xintSignedFrac**

$\frac{\text{Frac}}{f}$  ★ This is as `\xintFrac` except that a negative fraction has the sign put in front, not in the numerator.

`\[\xintFrac {-355/113}=\xintSignedFrac {-355/113}\]`

$$\frac{-355}{113} = -\frac{355}{113}$$

**29.12 \xintFwOver**

$\frac{\text{Frac}}{f}$  ★ This does the same as `\xintFrac` except that the `\over` primitive is used for the fraction (in case the denominator is not one; and a pair of braces contains the  $A\over B$  part). `\xintFwOver {178.000/256000000}` gives  $\frac{178000}{256000000}10^{-3}$ , `\xintFwOver {178.000/1}` gives  $178000 \cdot 10^{-3}$ , `\xintFwOver {3.5/5.7}` gives  $\frac{35}{57}$ , and `\xintFwOver {\xintNum {\xintFac{10}}/\xintiSqr{\xintFac {5}}}` gives 252.

**29.13 \xintSignedFwOver**

$\frac{\text{Frac}}{f}$  ★ This is as `\xintFwOver` except that a negative fraction has the sign put in front, not in the numerator.

`\[\xintFwOver {-355/113}=\xintSignedFwOver {-355/113}\]`

$$\frac{-355}{113} = -\frac{355}{113}$$

**29.14 \xintIrr**

$\frac{\text{Frac}}{f}$  ★ This puts the fraction into its unique irreducible form:

$$\xintIrr {178.256/256.178}=6856/9853 = \frac{6856}{9853}$$

Note that the current implementation does not cleverly first factor powers of 2 and 5, so input such as `\xintIrr {2/3[100]}` will make **xintfrac** do the Euclidean division of  $2 \cdot 10^{100}$  by 3, which is a bit stupid.

Starting with release 1.08, `\xintIrr` does not remove the trailing /1 when the output is an integer. This was deemed better for various (stupid?) reasons and thus the output format is now *always*  $A/B$  with  $B>0$ . Use `\xintPraw` on top of `\xintIrr` if it is needed to get rid

of a possible trailing /1. For display in math mode, use rather `\xintFrac{\xintIrr {f}}` or `\xintFwOver{\xintIrr {f}}`.

### 29.15 `\xintJrr`

$\frac{\text{num}}{x} \frac{\text{Frac}}{f}$  ★

This also puts the fraction into its unique irreducible form:

```
\xintJrr {178.256/256.178}=6856/9853
```

This is faster than `\xintIrr` for fractions having some big common factor in the numerator and the denominator.

```
\xintJrr {\xintiPow{\xintFac {15}}{3}/\xintiiPrdExpr {\xintFac{10}}{\xintFac{30}}{\xintFac{5}}\relax }=1001/51705840
```

But to notice the difference one would need computations with much bigger numbers than in this example. Starting with release 1.08, `\xintJrr` does not remove the trailing /1 when the output is an integer.

### 29.16 `\xintTrunc`

$\frac{\text{num}}{x} \frac{\text{Frac}}{f}$  ★

`\xintTrunc{x}{f}` returns the integral part, a dot, and then the first  $x$  digits of the decimal expansion of the fraction  $f$ . The argument  $x$  should be non-negative.

In the special case when  $f$  evaluates to 0, the output is 0 with no decimal point nor decimal digits, else the post decimal mark digits are always printed. A non-zero negative  $f$  which is smaller in absolute value than  $10^{-x}$  will give  $-0.000\dots$

```
\xintTrunc {16}{-803.2028/20905.298}=-0.0384210165289200
\xintTrunc {20}{-803.2028/20905.298}=-0.03842101652892008523
\xintTrunc {10}{\xintiPow {-11}{-11}}=-0.0000000000
\xintTrunc {12}{\xintiPow {-11}{-11}}=-0.0000000000003
\xintTrunc {12}{\xintAdd {-1/3}{3/9}}=0
```

The digits printed are exact up to and including the last one.

### 29.17 `\xintiTrunc`

$\frac{\text{num}}{x} \frac{\text{Frac}}{f}$  ★

`\xintiTrunc{x}{f}` returns the integer equal to  $10^x$  times what `\xintTrunc{x}{f}` would produce.

```
\xintiTrunc {16}{-803.2028/20905.298}=-384210165289200
\xintiTrunc {10}{\xintiPow {-11}{-11}}=0
\xintiTrunc {12}{\xintiPow {-11}{-11}}=-3
```

The difference between `\xintTrunc{0}{f}` and `\xintiTrunc{0}{f}` is that the latter never has the decimal mark always present in the former except for  $f=0$ . And `\xintTrunc{0}{-0.5}` returns “-0.” whereas `\xintiTrunc{0}{-0.5}` simply returns “0”.

### 29.18 `\xintXTrunc`

$\frac{\text{num}}{x} \frac{\text{Frac}}{f}$  ☆

`\xintXTrunc{x}{f}` is completely expandable but not  $f$ -expandable, as is indicated by the hollow star in the margin. It can not be used as argument to the other package macros, but is designed to be used inside an `\edef`, or rather a `\write`. Here is an example session where the user after some warming up checks that  $1/66049=1/257^2$  has period  $257*256=65792$  (it is also checked here that this is indeed the smallest period).

```
xxx:_xint $ etex -jobname worksheet-66049
```

## 29 Commands of the *xintfrac* package

```

This is pdfTeX, Version 3.1415926-2.5-1.40.14 (TeX Live 2013)
  restricted \write18 enabled.
**\relax
entering extended mode

*\input xintfrac.sty
(./xintfrac.sty (./xint.sty (./xinttools.sty)))
*\message{\xintTrunc {100}{1/71}}% Warming up!

0.01408450704225352112676056338028169014084507042253521126760563380281690140845
07042253521126760563380
*\message{\xintTrunc {350}{1/71}}% period is 35

0.01408450704225352112676056338028169014084507042253521126760563380281690140845
0704225352112676056338028169014084507042253521126760563380281690140845070422535
2112676056338028169014084507042253521126760563380281690140845070422535211267605
6338028169014084507042253521126760563380281690140845070422535211267605633802816
901408450704225352112676056338028169
*\edef\Z {\xintXTrunc {65792}{1/66049}}% getting serious...

*\def\trim 0.{ }\oodef\Z {\expandafter\trim\Z}% removing 0.

*\edef\W {\xintXTrunc {131584}{1/66049}}% a few seconds

*\oodef\W {\expandafter\trim\W}

*\oodef\ZZ {\expandafter\Z\Z}% doubling the period

*\ifx\W\ZZ \message{YES!}\else\message{BUG!}\fi % xint never has bugs...
YES!
*\message{\xintTrunc {260}{1/66049}}% check visually that 256 is not a period

0.00001514027464458205271843631243470756559523989765174340262532362337052794137
6856576178291874214598252812306015231116292449545034746930309315810988811337037
6538630410755651107511090251177156353616254598858423291798513225029902042423049
5541189117170585474420505
*\edef\X {\xintXTrunc {257*128}{1/66049}}% infix here ok, less than 8 tokens

*\oodef\X {\expandafter\trim\X}% we now have the first 257*128 digits

*\oodef\XX {\expandafter\X\X}% was 257*128 a period?

*\ifx\XX\Z \message{257*128 is a period}\else \message{257 * 128 not a period}\fi
257 * 128 not a period
*\immediate\write-1 {1/66049=0.\Z... (repeat)}

*\oodef\ZA {\xintNum {\Z}}% we remove the 0000, or we could use next \xintiMul

*\immediate\write-1 {10\string^65792-1=\xintiiMul {\ZA}{66049}}

*% This was slow :( I should write a multiplication, still completely

```

% expandable, but not f-expandable, which could be much faster on such cases.

\*\bye

No pages of output.

Transcript written on worksheet-66049.log.

xxx:\_xint \$

Using `\xintTrunc` rather than `\xintXTrunc` would be hopeless on such long outputs (and even `\xintXTrunc` needed of the order of seconds to complete here). But it is not worth it to use `\xintXTrunc` for less than hundreds of digits.

Fraction arguments to `\xintXTrunc` corresponding to a  $A/B[N]$  with a negative  $N$  are treated somewhat less efficiently (additional memory impact) than for positive or zero  $N$ . This is because the algorithm tries to work with the smallest denominator hence does not extend  $B$  with zeroes, and technical reasons lead to the use of some tricks.<sup>58</sup>

Contrarily to `\xintTrunc`, in the case of the second argument revealing itself to be exactly zero, `\xintXTrunc` will output  $0.000\dots$ , not  $0$ . Also, the first argument must be at least 1.

### 29.19 `\xintRound`

$\text{num}_x^{\text{Frac}} f$  ★

`\xintRound{x}{f}` returns the start of the decimal expansion of the fraction  $f$ , rounded to  $x$  digits precision after the decimal point. The argument  $x$  should be non-negative. Only when  $f$  evaluates exactly to zero does `\xintRound` return  $0$  without decimal point. When  $f$  is not zero, its sign is given in the output, also when the digits printed are all zero.

`\xintRound {16}{-803.2028/20905.298}=-0.0384210165289201`

`\xintRound {20}{-803.2028/20905.298}=-0.03842101652892008523`

`\xintRound {10}{\xintPow {-11}{-11}}=-0.0000000000`

`\xintRound {12}{\xintPow {-11}{-11}}=-0.0000000000004`

`\xintRound {12}{\xintAdd {-1/3}{3/9}}=0`

The identity `\xintRound {x}{-f}=-\xintRound {x}{f}` holds. And regarding  $(-11)^{-11}$  here is some more of its expansion:

$-0.00000000000350493899481392497604003313162598556370\dots$

### 29.20 `\xintiRound`

$\text{num}_x^{\text{Frac}} f$  ★

`\xintiRound{x}{f}` returns the integer equal to  $10^x$  times what `\xintRound{x}{f}` would return.

`\xintiRound {16}{-803.2028/20905.298}=-384210165289201`

`\xintiRound {10}{\xintPow {-11}{-11}}=0`

Differences between `\xintRound{0}{f}` and `\xintiRound{0}{f}`: the former cannot be used inside integer-only macros, and the latter removes the decimal point, and never returns  $-0$  (and removes all superfluous leading zeros.)

<sup>58</sup> Technical note: I do not provide an `\xintXFloat` because this would almost certainly mean having to clone the entire core division routines into a “long division” variant. But this could have given another approach to the implementation of `\xintXTrunc`, especially for the case of a negative  $N$ . Doing these things with  $\text{T}\text{E}\text{X}$  is an effort. Besides an `\xintXFloat` would be interesting only if also for example the square root routine was provided in an  $X$  version (I have not given thought to that). If feasible  $X$  routines would be interesting in the `\xintexpr` context where things are expanded inside `\curname... \endcurname`.

**29.21 `\xintFloor`**

$\frac{\text{Frac}}{f}$  ★ `\xintFloor {f}` returns the largest relative integer  $N$  with  $N \leq f$ .  
`\xintFloor {-2.13}=-3, \xintFloor {-2}=-2, \xintFloor {2.13}=2`

**29.22 `\xintCeil`**

$\frac{\text{Frac}}{f}$  ★ `\xintCeil {f}` returns the smallest relative integer  $N$  with  $N > f$ .  
`\xintCeil {-2.13}=-2, \xintCeil {-2}=-2, \xintCeil {2.13}=3`

**29.23 `\xintTFrac`**

$\frac{\text{Frac}}{f}$  ★ `\xintTFrac{f}` returns the fractional part,  $f=\text{trunc}(f)+\text{frac}(f)$ . The T stands for ‘Trunc’, and there could similar macros associated to ‘Round’, ‘Floor’, and ‘Ceil’. Inside `\xintexpr...\relax`, the function `frac` is mapped to `\xintTFrac`. Inside `\xintfloatexpr...\relax`, `frac` first applies `\xintTFrac` to its argument (which may be in float format, or an exact fraction), and only next makes the float conversion.

`\xintTFrac {1235/97}=71/97[0]    \xintTFrac {-1235/97}=-71/97[0]`  
`\xintTFrac {1235.973}=973/1[-3]    \xintTFrac {-1235.973}=-973/1[-3]`  
`\xintTFrac {1.122435727e5}=5727/1[-4]`

**29.24 `\xintE`**

$\frac{\text{Frac}}{f} \frac{\text{num}}{x}$  ★ `\xintE {f}{x}` multiplies the fraction  $f$  by  $10^x$ . The *second* argument  $x$  must obey the  $\text{T}_{\text{E}}\text{X}$  bounds. Example:

`\count 255 123456789 \xintE {10}{\count 255}->10/1[123456789]`

Be careful that for obvious reasons such gigantic numbers should not be given to `\xint-Num`, or added to something with a widely different order of magnitude, as the package always works to get the *exact* result. There is *no problem* using them for *float* operations:

`\xintFloatAdd {1e1234567890}{1}=1.000000000000000e1234567890`

**29.25 `\xintFloatE`**

$\frac{\text{num}}{[x]} \frac{\text{Frac}}{f} \frac{\text{num}}{x}$  ★ `\xintFloatE [P]{f}{x}` multiplies the input  $f$  by  $10^x$ , and converts it to float format according to the optional first argument or current value of `\xintDigits`.

`\xintFloatE {1.23e37}{53}=1.230000000000000e90`

**29.26 `\xintDigits`, `\xinttheDigits`**

The syntax `\xintDigits := D;` (where spaces do not matter) assigns the value of  $D$  to the number of digits to be used by floating point operations. The default is 16. The maximal value is 32767. The macro `\xinttheDigits` serves to print the current value.

**29.27 `\xintFloat`**

$\frac{\text{num}}{[x]} \frac{\text{Frac}}{f}$  ★ The macro `\xintFloat [P]{f}` has an optional argument  $P$  which replaces the current value of `\xintDigits`. The (rounded truncation of the) fraction  $f$  is then printed in scientific form, with  $P$  digits, a lowercase  $e$  and an exponent  $N$ . The first digit is from 1 to 9, it is preceded by an optional minus sign and is followed by a dot and  $P-1$  digits, the trailing

zeros are not trimmed. In the exceptional case where the rounding went to the next power of ten, the output is  $10.0\dots0eN$  (with a sign, perhaps). The sole exception is for a zero value, which then gets output as  $0.e0$  (in an `\xintCmp` test it is the only possible output of `\xintFloat` or one of the ‘Float’ macros which will test positive for equality with zero).

`\xintFloat[32]{1234567/7654321}=1.6129020457856418616360615134902e-1`  
`\xintFloat[32]{1/\xintFac{100}}=1.0715102881254669231835467595192e-158`

The argument to `\xintFloat` may be an `\xinttheexpr`-ession, like the other macros; only its final evaluation is submitted to `\xintFloat`: the inner evaluations of chained arguments are not at all done in ‘floating’ mode. For this one must use `\xintthefloatexpr`.

### 29.28 `\xintAdd`

$\frac{\text{Frac}}{f} \frac{\text{Frac}}{f}$  ★

The original macro is extended to accept fractions on input. Its output will now always be in the form  $A/B[n]$ . The original is available as `\xintiAdd`.

### 29.29 `\xintFloatAdd`

$\left[\frac{\text{num}}{x}\right] \frac{\text{Frac}}{f} \frac{\text{Frac}}{f}$  ★

`\xintFloatAdd [P]{f}{g}` first replaces  $f$  and  $g$  with their float approximations, with 2 safety digits. It then adds exactly and outputs in float format with precision  $P$  (which is optional) or `\xintDigits` if  $P$  was absent, the result of this computation.

### 29.30 `\xintSub`

$\frac{\text{Frac}}{f} \frac{\text{Frac}}{f}$  ★

The original macro is extended to accept fractions on input. Its output will now always be in the form  $A/B[n]$ . The original is available as `\xintiSub`.

### 29.31 `\xintFloatSub`

$\left[\frac{\text{num}}{x}\right] \frac{\text{Frac}}{f} \frac{\text{Frac}}{f}$  ★

`\xintFloatSub [P]{f}{g}` first replaces  $f$  and  $g$  with their float approximations, with 2 safety digits. It then subtracts exactly and outputs in float format with precision  $P$  (which is optional), or `\xintDigits` if  $P$  was absent, the result of this computation.

### 29.32 `\xintMul`

$\frac{\text{Frac}}{f} \frac{\text{Frac}}{f}$  ★

The original macro is extended to accept fractions on input. Its output will now always be in the form  $A/B[n]$ . The original, only for big integers, and outputting a big integer, is available as `\xintiMul`.

### 29.33 `\xintFloatMul`

$\left[\frac{\text{num}}{x}\right] \frac{\text{Frac}}{f} \frac{\text{Frac}}{f}$  ★

`\xintFloatMul [P]{f}{g}` first replaces  $f$  and  $g$  with their float approximations, with 2 safety digits. It then multiplies exactly and outputs in float format with precision  $P$  (which is optional), or `\xintDigits` if  $P$  was absent, the result of this computation.

### 29.34 `\xintSqr`

$\frac{\text{Frac}}{f}$  ★

The original macro is extended to accept a fraction on input. Its output will now always be in the form  $A/B[n]$ . The original which outputs only big integers is available as `\xintiSqr`.

**29.35 \xintDiv**

$$\frac{\text{Frac}}{f} \frac{\text{Frac}}{f} \star$$

`\xintDiv{f}{g}` computes the fraction  $f/g$ . As with all other computation macros, no simplification is done on the output, which is in the form  $A/B[n]$ .

**29.36 \xintFloatDiv**

$$\left[\frac{\text{num}}{x}\right] \frac{\text{Frac}}{f} \frac{\text{Frac}}{f} \star$$

`\xintFloatDiv [P]{f}{g}` first replaces  $f$  and  $g$  with their float approximations, with 2 safety digits. It then divides exactly and outputs in float format with precision  $P$  (which is optional), or `\xintDigits` if  $P$  was absent, the result of this computation.

**29.37 \xintFac**

$$\frac{\text{Num}}{f} \star$$

The original is extended to allow a fraction on input but this fraction  $f$  must simplify to a integer  $n$  (non negative and at most 999999, but already 1000000! is prohibitively time-costly). On output  $n!$  (no trailing  $/1[0]$ ). The original macro (which has less overhead) is still available as `\xintiFac`.

**29.38 \xintPow**

$$\frac{\text{Frac}}{f} \frac{\text{Num}}{f} \star$$

`\xintPow{f}{g}`: the original macro is extended to accept fractions on input. The output will now always be in the form  $A/B[n]$  (even when the exponent vanishes: `\xintPow{2/3}{0}=1/1[0]`). The original is available as `\xintiPow`.

The exponent is allowed to be input as a fraction but it must simplify to an integer: `\xintPow{2/3}{10/2}=32/243[0]`. This integer will be checked to not exceed 1000000. Indeed  $2^{500000}$  already has 15052 digits, and squaring such a number would take hours (I think) with the expandable routine of *xint*.

**29.39 \xintFloatPow**

$$\left[\frac{\text{num}}{x}\right] \frac{\text{Frac}}{f} \frac{\text{num}}{x} \star$$

`\xintFloatPow [P]{f}{x}` uses either the optional argument  $P$  or the value of `\xintDigits`. It computes a floating approximation to  $f^x$ . The precision  $P$  must be at least 1, naturally.

The exponent  $x$  will be fed to a `\numexpr`, hence count registers are accepted on input for this  $x$ . And the absolute value  $|x|$  must obey the  $\text{T}_{\text{E}}\text{X}$  bound. For larger exponents use the slightly slower routine `\xintFloatPower` which allows the exponent to be a fraction simplifying to an integer and does not limit its size. This slightly slower routine is the one to which  $^$  is mapped inside `\xintthefloatexpr... \relax`.

The macro `\xintFloatPow` chooses dynamically an appropriate number of digits for the intermediate computations, large enough to achieve the desired accuracy (hopefully).

`\xintFloatPow [8]{3.1415}{1234567890}=1.6122066e613749456`

**29.40 \xintFloatPower**

$$\left[\frac{\text{num}}{x}\right] \frac{\text{Frac}}{f} \frac{\text{Num}}{f} \star$$

`\xintFloatPower[P]{f}{g}` computes a floating point value  $f^g$  where the exponent  $g$  is not constrained to be at most the  $\text{T}_{\text{E}}\text{X}$  bound 2147483647. It may even be a fraction  $A/B$  but must simplify to a (possibly big) integer.

`\xintFloatPower [8]{1.0000000000001}{1e12}=2.7182818e0`

```
\xintFloatPower [8]{3.1415}{3e9}=1.4317729e1491411192
```

Note that  $3e9 > 2^{31}$ . But the number following e in the output must at any rate obey the  $\text{\TeX}$  2147483647 bound.

Inside an `\xintfloatexpr`-ession, `\xintFloatPower` is the function to which `^` is mapped. The exponent may then be something like  $(144/3/(1.3-.5)-37)$  which is, in disguise, an integer.

The intermediate multiplications are done with a higher precision than `\xintDigits` or the optional `P` argument, in order for the final result to hopefully have the desired accuracy.

### 29.41 `\xintFloatSqrt`

$\left[\begin{smallmatrix} \text{num} \\ x \end{smallmatrix}\right] \overset{\text{Frac}}{f} \star$

`\xintFloatSqrt[P]{f}` computes a floating point approximation of  $\sqrt{f}$ , either using the optional precision `P` or the value of `\xintDigits`. The computation is done for a precision of at least 17 figures (and the output is rounded if the asked-for precision was smaller).

```
\xintFloatSqrt [50]{12.3456789e12}
```

```
≈ 3.5136418286444621616658231167580770371591427181243e6
```

```
\xintDigits:=50;\xintFloatSqrt {\xintFloatSqrt {2}}
```

```
≈ 1.1892071150027210667174999705604759152929720924638e0
```

### 29.42 `\xintSum`

$f \rightarrow * \overset{\text{Frac}}{f} \star$

The original command is extended to accept fractions on input and produce fractions on output. The output will now always be in the form `A/B[n]`. The original, for big integers only (in strict format), is available as `\xintiiSum`.

### 29.43 `\xintPrd`

$f \rightarrow * \overset{\text{Frac}}{f} \star$

The original is extended to accept fractions on input and produce fractions on output. The output will now always be in the form `A/B[n]`. The original, for big integers only (in strict format), is available as `\xintiiPrd`.

### 29.44 `\xintCmp`

$\overset{\text{Frac}}{f} \overset{\text{Frac}}{f} \star$

The macro is extended to fractions. Its output is still either `-1`, `0`, or `1` with no forward slash nor trailing `[n]`.

For choosing branches according to the result of comparing `f` and `g`, the following syntax is recommended: `\xintSgnFork{\xintCmp{f}{g}}{code for f<g}{code for f=g}{code for f>g}`.

### 29.45 `\xintIsOne`

$\overset{\text{Frac}}{f} \star$

See `\xintIsOne` (subsection 28.17).

### 29.46 `\xintGeq`

$\overset{\text{Frac}}{f} \overset{\text{Frac}}{f} \star$

The macro is extended to fractions. Beware that the comparison is on the *absolute values* of the fractions. Can be used as: `\xintSgnFork{\xintGeq{f}{g}}{code for |f|<|g|}{code for |f|≥|g|}`

## 29.47 \xintMax

$\frac{f}{f}$  ★ The macro is extended to fractions. But now `\xintMax {2}{3}` returns 3/1[0]. The original, for use with (possibly big) integers only, is available as `\xintiMax`: `\xintiMax {2}{3}=3`.

## 29.48 \xintMaxof

$f \rightarrow *^{\text{Frac}} f$  ★ See `\xintMaxof` (subsection 28.26).

## 29.49 \xintMin

$\frac{\frac{1}{2}}{\frac{1}{3}}$   $\frac{1}{2}$   $\frac{1}{3}$  ★ The macro is extended to fractions. The original, for (big) integers only, is available as `\xintiMin`.

## 29.50 \xintMinof

$f \rightarrow *^{\text{Frac}} f$  ★ See `\xintMinof` (subsection 28.28).

## 29.51 \xintAbs

$\frac{\text{Frac}}{f}$  ★ The macro is extended to fractions. The original, for (big) integers only, is available as `\xintiAbs`. Note that `\xintiAbs {-2}=2/1 [0]` whereas `\xintiAbs {-2}=2`.

## 29.52 \xintSgn

**$\frac{\text{Frac}}{f}$**  ★ The macro is extended to fractions. Naturally, its output is still either -1, 0, or 1 with no forward slash nor trailing [n].

**29.53** \xint0pp

$\frac{\text{Frac}}{f}$  ★ The macro is extended to fractions. The original is available as `\xintiOpp`. Note that `\xintiOpp {3}` now outputs `-3/1[0]` whereas `\xintiOpp {3}` returns `-3`.

29.54 \xintDivision, \xintQuo, \xintRem, \xintFDg, \xintLDg,  
 \xintMON, \xintMMON, \xintOdd

$\frac{f}{f}$  ★ These macros accept a fraction on input if this fraction in fact reduces to an integer (if not an `\xintError:NotAnInteger` will be raised). There is no difference in the format of the outputs, which are still (possibly big) integers without fraction slash nor trailing [n], the sole difference is in the extended range of accepted inputs.

All have variants whose names start with `xintii` rather than `xint`; these variants accept on input only integers in the strict format (they do not use `\xintNum`). They thus have less overhead, and may be used when one is dealing exclusively with (big) integers. These variants are already available in `xint`, there is no need for `xintfrac` to be loaded.

```
\xintNum {1e80}
```

[illegible]

## 30 Expandable expressions with the **xintexpr** package

The **xintexpr** package was first released with version 1.07 of the **xint** bundle. It loads automatically **xintfrac**, hence also **xint** and **xinttools**.

The syntax is described in [section 24](#) and [section 25](#).

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### 30.1 The **\xintexpr** expressions

**x ★** An **xintexpr** expression is a construct **\xintexpr** $\langle expandable\_expression \rangle$ **\relax** where the expandable expression is read and completely expanded from left to right.

During this parsing, braced sub-content  $\{\langle expandable \rangle\}$  may be serving as a macro parameter, or a branch of the **?** two-way and **:** three-way operators; else it is treated in a special manner:

1. it is allowed to occur only at the spots where numbers are legal,
2. the  $\langle expandable \rangle$  contents is then completely expanded as if it were put in a **\csname**..**\endcsname**,<sup>59</sup> thus it escapes entirely the parser scope and infix notations will not be recognized except if the expanded macros know how to handle them by themselves,
3. and this complete expansion *must* produce a number or a fraction, possibly with decimal mark and trailing **[n]**, the scientific notation is *not* authorized.

Braces are the only way to input some number or fraction with a trailing **[n]** as square brackets are *not* accepted in a **\xintexpr**..**\relax** if not within such braces.

An **\xintexpr**..**\relax** *must* end in a **\relax** (which will be absorbed). Like a **\numexpr** expression, it is not printable as is, nor can it be directly employed as argument to the other package macros. For this one must use one of the two equivalent forms:

- x ★** • **\xinttheexpr** $\langle expandable\_expression \rangle$ **\relax**, or
- x ★** • **\xintthe****\xintexpr** $\langle expandable\_expression \rangle$ **\relax**.

<sup>59</sup> well, actually it *is* put in such a **\csname**..**\endcsname**.

The computations are done *exactly*, and with no simplification of the result. The output format for the result can be coded inside the expression through the use of one of the functions `round`, `trunc`, `float`, `reduce`.<sup>60</sup> Here are some examples

```
\xinttheexpr 1/5!-1/7!-1/9!\relax=1784764800/219469824000[0]
\xinttheexpr round(1/5!-1/7!-1/9!,18)\relax=0.008132164902998236
\xinttheexpr float(1/5!-1/7!-1/9!,18)\relax=813216490299823633[-20]
\xinttheexpr reduce(1/5!-1/7!-1/9!)\relax=2951/362880
\xinttheexpr 1.99^-2 - 2.01^-2 \relax=800/1599920001[4]
\xinttheexpr round(1.99^-2 - 2.01^-2, 10)\relax=0.0050002500
```

- the expression may contain arbitrarily many levels of nested parenthesized sub-expressions,
- sub-contents giving numbers of fractions should be either
  1. parenthesized,
  2. a sub-expression `\xintexpr...\relax`,
  3. or within braces.

New!

→ When a sub-expression is hit against in the midst of absorbing the digits of a number, a multiplication sign is tacitly implied. No such tacit multiplication is implied by an opening parenthesis.

- an expression can not be given as argument to the other package macros, nor printed, for this one must use `\xinttheexpr...\relax` or `\xintthe\xintexpr...\relax`,
- one does not use `\xinttheexpr...\relax` as a sub-constituent of an `\xintexpr...\relax` (or `\xinttheexpr...\relax`) but simply `\xintexpr...\relax`,
- each **xintexpr** expression is completely expandable and obtains its result in two expansion steps.

In an algorithm implemented non-expandably, one may define macros to expand to infix expressions to be used within others. One then has the choice between parentheses or `\xintexpr...\relax`: `\def\x {(\a+\b)}` or `\def\x {\xintexpr \a+\b\relax}`. The latter is the better choice as it allows also to be prefixed with `\xintthe`. Furthermore, if `\a` and `\b` are already defined `\oodef\x {\xintexpr \a+\b\relax}` will do the computation on the spot.

## 30.2 `\numexpr` or `\dimexpr` expressions, count and dimension registers and variables

Count registers, count control sequences, dimen registers, dimen control sequences, skips and skip control sequences, `\numexpr`, `\dimexpr`, `\glueexpr` can be inserted directly, they will be unpacked using `\number` (which gives the internal value in terms of scaled points for the dimensional variables: 1 pt = 65536 sp; stretch and shrink components are thus discarded). Tacit multiplication is implied, when a number or decimal number prefixes such a register or control sequence.

<sup>60</sup> In `round` and `trunc` the second optional parameter is the number of digits of the fractional part; in `float` it is the total number of digits of the mantissa.

L<sup>A</sup>T<sub>E</sub>X lengths are skip control sequences and L<sup>A</sup>T<sub>E</sub>X counters should be inserted using `\value`.

In the case of numbered registers like `\count255` or `\dimen0`, the resulting digits will be re-parsed, so for example `\count255 0` is like `100` if `\the\count255` would give `10`. Control sequences define complete numbers, thus cannot be extended that way with more digits, on the other hand they are more efficient as they avoid the re-parsing of their unpacked contents.

A token list variable must be prefixed by `\the`, it will not be unpacked automatically (the parser will actually try `\number`, and thus fail). Do not use `\the` but only `\number` with a `dimen` or `skip`, as the `\xintexpr` parser doesn't understand `pt` and its presence is a syntax error. To use a dimension expressed in terms of points or other T<sub>E</sub>X recognized units, incorporate it in `\dimexpr... \relax`.

If one needs to optimize, `1.72\dimexpr 3.2pt\relax` is less efficient than `1.72*{\number\dimexpr 3.2pt\relax}` as the latter avoids re-parsing the digits of the representation of the dimension as scaled points.

```
\xinttheexpr 1.72\dimexpr 3.2pt\relax/2.71828\relax=
\xinttheexpr 1.72*{\number\dimexpr 3.2pt\relax}/2.71828\relax
36070980/271828[3]=36070980/271828[3]
```

Regarding how dimensional expressions are converted by T<sub>E</sub>X into scaled points see [section 13](#).

### 30.3 Catcodes and spaces

#### 30.3.1 `\xintexprSafeCatcodes`

Active characters will interfere with `\xintexpr`-essions. One may prefix them with `\string` within `\xintexpr... \relax`, thus preserving expandability, or there is the non-expandable `\xintexprSafeCatcodes` which can be issued before the use of `\xintexpr`. This command sets (not globally) the catcodes of the relevant characters to safe values. This is used internally by `\xintNewExpr` (restoring the catcodes on exit), hence `\xintNewExpr` does not have to be protected against active characters.

#### 30.3.2 `\xintexprRestoreCatcodes`

Restores the catcodes to the earlier state.

Unbraced spaces inside an `\xinttheexpr... \relax` should mostly be innocuous (except inside macro arguments).

`\xintexpr` and `\xinttheexpr` are for the most part agnostic regarding catcodes: (unbraced) digits, binary operators, minus and plus signs as prefixes, dot as decimal mark, parentheses, may be indifferently of catcode letter or other or subscript or superscript, ..., it doesn't matter.<sup>61</sup>

The characters `+, -, *, /, ^, !, &, |, ?, :, <, >, =, (, )`, the dot and the comma should not be active as everything is expanded along the way. If one of them is active, it should be prefixed with `\string`.

<sup>61</sup> Furthermore, although `\xintexpr` uses `\string`, it is (we hope) escape-char agnostic.

Digits, slash, square brackets, minus sign, in the output from an `\xinttheexpr` are all of catcode 12. For `\xintthefloatexpr` the ‘e’ in the output is of catcode 11.

A macro with arguments will expand and grab its arguments before the parser may get a chance to see them, so the situation with catcodes and spaces is not the same within such macro arguments (or within braces used to protect square brackets).

### 30.4 Expandability, `\xinteval`

As is the case with all other package macros `\xintexpr` expands in two steps to its final (non-printable) result; and similarly for `\xinttheexpr`.

As explained above the expressions should contain only expandable material, except that braces are allowed when they enclose either a fraction (or decimal number) or something arbitrarily complicated but expanding (in a manner compatible to an expansion only context) to such a fraction or decimal number.

The once expanded `\xintexpr` is `\romannumeral0\xinteval`. And there is similarly `\xintieval`, `\xintiieval`, and `\xintfloateval`. For the other cases one can use `\romannumeral-` ‘0’ as prefix.

New! → For the construction of expandable algorithms using chains of `\xinteval`-uations see [subsection 27.22](#).

An expression can only be legally finished by a `\relax` token, which will be absorbed.

### 30.5 Memory considerations

The parser creates an undefined control sequence for each intermediate computation (this does not refer to the intermediate steps needed in the evaluations of the `\xintAdd`, `\xintMul`, etc... macros corresponding to the infix operators, but only to each conversion of such an infix operator into a computation). So, a moderately sized expression might create 10, or 20 such control sequences. On my  $\text{\TeX}$  installation, the memory available for such things is of circa 200,000 multi-letter control words. So this means that a document containing hundreds, perhaps even thousands of expressions will compile with no problem.

Besides the hash table, also  $\text{\TeX}$  main memory is impacted. Thus, if **xintexpr** is used for computing plots<sup>62</sup>, this may cause a problem.

There is a solution.<sup>63</sup>

A document can possibly do tens of thousands of evaluations only if some formulas are being used repeatedly, for example inside loops, with counters being incremented, or with data being fetched from a file. So it is the same formula used again and again with varying numbers inside.

With the `\xintNewExpr` command, it is possible to convert once and for all an expression containing parameters into an expandable macro with parameters. Only this initial definition of this macro actually activates the `\xintexpr` parser and will (very moderately) impact the hash-table: once this unique parsing is done, a macro with parameters is produced which is built-up recursively from the `\xintAdd`, `\xintMul`, etc... macros, exactly as it would be necessary to do without the facilities of the **xintexpr** package.

<sup>62</sup> this is not very probable as so far **xint** does not include a mathematical library with floating point calculations, but provides only the basic operations of algebra. <sup>63</sup> which convinced me that I could stick with the parser implementation despite its potential impact on the hash-table and other parts of  $\text{\TeX}$ ’s memory.

### 30.6 The `\xintNewExpr` command

The command is used as:

`\xintNewExpr{\myformula}[n]{\langle stuff \rangle}`, where

- $\langle stuff \rangle$  will be inserted inside `\xinttheexpr . . . \relax`,
- $n$  is an integer between zero and nine, inclusive, and tells how many parameters will `\myformula` have (it is *mandatory* even if  $n=0$ <sup>64</sup>)
- the placeholders  $\#1, \#2, \dots, \#n$  are used inside  $\langle stuff \rangle$  in their usual rôle.

The macro `\myformula` is defined without checking if it already exists, L<sup>A</sup>T<sub>E</sub>X users might prefer to do first `\newcommand*\myformula {}` to get a reasonable error message in case `\myformula` already exists.

The definition of `\myformula` made by `\xintNewExpr` is global. The protection against active characters is done automatically.

It will be a completely expandable macro entirely built-up using `\xintAdd`, `\xintSub`, `\xintMul`, `\xintDiv`, `\xintPow`, etc...as corresponds to the expression written with the infix operators.

A “formula” created by `\xintNewExpr` is thus a macro whose parameters are given to a possibly very complicated combination of the various macros of `xint` and `xintfrac`; hence one can not use infix notation inside the arguments, as in for example `\myformula {28^7-35^12}` which would have been allowed by

```
\def\myformula #1{\xinttheexpr (#1)^3\relax}
```

One will have to do `\myformula {\xinttheexpr 28^7-35^12\relax}`, or redefine `\myformula` to have more parameters.

```
\xintNewExpr\DET[9]{ #1*#5*#9+#2*#6*#7+#3*#4*#8-#1*#6*#8-#2*#4*#9-#3*#5*#7 }
```

```
\meaning\DET:macro:#1#2#3#4#5#6#7#8#9->\romannumeral-'0\xintSub{\xintSub{\xintSub{\xintAdd{\xintAdd{\xintMul{\xintMul{#1}{#5}}}{#9}}{\xintMul{\xintMul{#2}{#6}}}{#7}}{\xintMul{\xintMul{#3}{#4}}{#8}}}{\xintMul{\xintMul{#1}{#6}}{#8}}{\xintMul{\xintMul{#2}{#4}}{#9}}{\xintMul{\xintMul{#3}{#5}}{#7}}
```

$$\backslash \text{xintNum}\{\backslash \text{DET } \{1\}\{1\}\{1\}\{10\}\{-10\}\{5\}\{11\}\{-9\}\{6\}\}=0$$
$$\text{\xintNum}\{\text{\DET } \{1\}\{2\}\{3\}\{10\}\{0\}\{-10\}\{21\}\{2\}\{-17\}\}=0$$

*Remark:* `\meaning` has been used within the argument to a `\printnumber` command, to avoid going into the right margin, but this zaps all spaces originally in the output from `\meaning`. Here is as an illustration the raw output of `\meaning` on the previous example:

```
macro:#1#2#3#4#5#6#7#8#9->\romannumeral -‘0\xintSub {\xintSub {\xintSub
{\xintAdd {\xintAdd {\xintMul {\xintMul {#1}{#5}}{#9}}{\xintMul {\xintMul
{#2}{#6}}{#7}}}{\xintMul {\xintMul {#3}{#4}}{#8}}}{\xintMul {\xintMul {#1}{#6}}{#8}}}{\xin
Mul {\xintMul {#2}{#4}}{#9}}}{\xintMul {\xintMul {#3}{#5}}{#7}}
```

This is why `\printnumber` was used, to have breaks across lines.

<sup>64</sup> there is some use for `\xintNewExpr[0]` compared to an `\edef` as `\xintNewExpr` has some built-in catcode protection.

### 30.6.1 Use of conditional operators

The 1.09a conditional operators `?` and `:` cannot be parsed by `\xintNewExpr` when they contain macro parameters `#1, ..., #9` within their scope. However replacing them with the functions `if` and, respectively `ifsgn`, the parsing should succeed. And the created macro will *not evaluate the branches to be skipped*, thus behaving exactly like `?` and `:` would have in the `\xintexpr`.

```
\xintNewExpr\Formula [3]
{ if((#1>#2) & (#2>#3), sqrt(#1-#2)*sqrt(#2-#3), #1^2+#3/#2) }
\meaning\Formula:macro:#1#2#3->\romannumeral-'0\xintifNotZero{\xintAND{
\xintGt{#1}{#2}}{\xintGt{#2}{#3}}}{\xintMul{\XINTinFloatSqrt[\XINTdigit
s]{\xintSub{#1}{#2}}{\XINTinFloatSqrt[\XINTdigits]{\xintSub{#2}{#3}}}}
{\xintAdd{\xintPow{#1}{2}}{\xintDiv{#3}{#2}}}
```

This formula (with `\xintifNotZero`) will gobble the false branch.

Remark: this `\XINTinFloatSqrt` macro is a non-user package macro used internally within `\xintexpr`-essions, it produces the result in `A[n]` form rather than in scientific notation, and for reasons of the inner workings of `\xintexpr`-essions, this is necessary; a hand-made macro would have used instead the equivalent `\xintFloatSqrt`.

Another example

```
\xintNewExpr\myformula [3]
{ ifsgn(#1,#2/#3,#2-#3,#2*#3) }
macro:#1#2#3->\romannumeral-'0\xintifSgn{#1}{\xintDiv{#2}{#3}}{\xintSub
{#2}{#3}}{\xintMul{#2}{#3}}
```

Again, this macro gobbles the false branches, as would have the operator `:` inside an `\xintexpr`-ession.

### 30.6.2 Use of macros

For macros to be inserted within such a created **xint**-formula command, there are two cases:

- the macro does not involve the numbered parameters in its arguments: it may then be left as is, and will be evaluated once during the construction of the formula,
- it does involve at least one of the parameters as argument. Then:
  1. the whole thing (macro + argument) should be braced (not necessary if it is already included into a braced group),
  2. the macro should be coded with an underscore `_` in place of the backslash `\`.
  3. the parameters should be coded with a dollar sign `$1`, `$2`, etc...

Here is a silly example illustrating the general principle (the macros here have equivalent functional forms which are more convenient; but some of the more obscure package macros of **xint** dealing with integers do not have functions pre-defined to be in correspondance with them):

```
\xintNewExpr\myformI[2]{ {_xintRound{$1}{$2}} - {_xintTrunc{$1}{$2}} }
\meaning\myformI:
macro:#1#2->\romannumeral -'0\xintSub {\xintRound {#1}{#2}}{\xintTrunc {#1}{#2}}
```

```
\xintNewIIExpr\formula [3]{rem(#1,quo({_the_numexpr $2_relax},#3))}
\meaning\formula:
macro:#1#2#3->\romannumeral -'0\xintiiRem {#1}{\xintiiQuo {\the \numexpr
#2\relax }{#3}}
```

### 30.7 **\xintiexpr**, **\xinttheiexpr**

- x ★** Equivalent to doing `\xintexpr round(...)\relax`. Thus, only the final result is rounded to an integer. Half integers are rounded towards  $+\infty$  for positive numbers and towards  $-\infty$  for negative ones. Can be used on comma separated lists of expressions.

**1.09i warning** → Initially baptized `\xintnumexpr`, `\xintthenumexpr` but I am not too happy about this choice of name; one should keep in mind that `\numexpr`'s integer division rounds, whereas in `\xintiexpr`, the `/` is an exact fractional operation, and only the final result is rounded to an integer.

So `\xintnumexpr`, `\xintthenumexpr` are deprecated, and although still provided for the time being this might change in the future.

### 30.8 **\xintiiexpr**, **\xinttheiexpr**

- x ★** This variant maps `/` to the euclidean quotient and deals almost only with (long) integers. It uses the 'ii' macros for addition, subtraction, multiplication, power, square, sums, products, euclidean quotient and remainder. The `round` and `trunc`, in the presence of the second optional argument, are mapped to `\xintiRound`, respectively `\xintiTrunc`, hence they always produce (long) integers.

To input a fraction to `round`, `trunc`, `floor` or `ceil` one can use braces, else the `/` will do the euclidean quotient. The minus sign should be put together with the fraction: `round(-{30/18})` is illegal (even if the fraction had been an integer), use `round({-30/18})=-2`.

Decimal numbers are allowed only if postfixed immediately with `e` or `E`, the number will then be truncated to an integer after multiplication by the power of ten with exponent the number following `e` or `E`.

```
\xinttheiexpr 13.4567e3+10000123e-3\relax=23456
```

A fraction within braces should be followed immediately by an `e` (or inside a `round`, `trunc`, etc...) to convert it into an integer as expected by the main operations. The truncation is only done after the `e` action.

The `reduce` function is not available and will raise an error. The `frac` function also. The `sqr` function is mapped to `\xintiSqrt`.

Numbers in float notation, obtained via a macro like `\xintFloatSqrt`, are a bit of a challenge: they can not be within braces (this has been mentioned already, `e` is not legal within braces) and if not braced they will be truncated when the parser meets the `e`. The way out of the dilemma is to use a sub-expression:

```
\xinttheiexpr \xintFloatSqrt{2}\relax=1
\xinttheiexpr \xintexpr\xintFloatSqrt{2}\relax e10\relax=14142135623
\xinttheiexpr round(\xintexpr\xintFloatSqrt{2}\relax,10)\relax=14142135624
(recall that round is mapped within \xintiiexpr.. \relax to \xintiRound which always
outputs an integer).
```

The whole point of `\xintiiexpr` is to gain some speed in integer only algorithms, and the above explanations related to how to use fractions therein are a bit peripheral.

We observed of the order of 30% speed gain when dealing with numbers with circa one hundred digits, but this gain decreases the longer the manipulated numbers become and becomes negligible for numbers with thousand digits: the overhead from parsing fraction format is little compared to other expensive aspects of the expandable shuffling of tokens.

### 30.9 `\xintboolexpr`, `\xinttheboolexpr`

- x* ★ Equivalent to doing `\xintexpr ... \relax` and returning 1 if the result does not vanish, and 0 if the result is zero. As `\xintexpr`, this can be used on comma separated lists of expressions, and will return a comma separated list of 0's and 1's.

### 30.10 `\xintfloatexpr`, `\xintthefloatexpr`

- x* ★ `\xintfloatexpr ... \relax` is exactly like `\xintexpr ... \relax` but with the four binary operations and the power function mapped to `\xintFloatAdd`, `\xintFloatSub`, `\xintFloatMul`, `\xintFloatDiv` and `\xintFloatPower`. The precision is from the current setting of `\xintDigits` (it can not be given as an optional parameter).

Currently, the factorial function hasn't yet a float version; so inside `\xintthefloatexpr ... \relax, n!` will be computed exactly. Perhaps this will be improved in a future release.

Note that `1.0000000001` and `(1+1e-9)` will not be equivalent for `D=\xinttheDigits` set to nine or less. Indeed the addition implicit in `1+1e-9` (and executed when the closing parenthesis is found) will provoke the rounding to 1. Whereas `1.0000000001`, when found as operand of one of the four elementary operations is kept with `D+2` digits, and even more for the power function.

```
\xintDigits:= 9; \xintthefloatexpr (1+1e-9)-1\relax=0.e0
\xintDigits:= 9; \xintthefloatexpr 1.0000000001-1\relax=1.00000000e-9
For the fun of it: \xintDigits:=20;
\xintthefloatexpr (1+1e-7)^1e7\relax=2.7182816925449662712e0
\xintDigits:=36;
\xintthefloatexpr ((1/13+1/121)*(1/179-1/173))/(1/19-1/18)\relax
5.64487459334466559166166079096852897e-3
\xintFloat{\xinttheexpr ((1/13+1/121)*(1/179-1/173))/(1/19-1/18)\relax}
5.64487459334466559166166079096852912e-3
```

The latter result is the rounding of the exact result. The previous one has rounding errors coming from the various roundings done for each sub-expression. It was a bit funny to discover that maple, configured with `Digits:=36`; and with decimal dots everywhere to let it input the numbers as floats, gives exactly the same result with the same rounding errors as does `\xintthefloatexpr`!

Using `\xintthefloatexpr` only pays off compared to using `\xinttheexpr` followed with `\xintFloat` if the computations turn out to involve hundreds of digits. For elementary calculations with hand written numbers (not using the scientific notation with exponents differing greatly) it will generally be more efficient to use `\xinttheexpr`. The situation is quickly otherwise if one starts using the Power function. Then, `\xintthefloat` is often useful; and sometimes indispensable to achieve the (approximate) computation in reasonable time.

We can try some crazy things:

```
\xintDigits:=12;\xintthefloatexpr 1.0000000000000001^1e15\relax
2.71828182846e0
```

Contrarily to some professional computing software which are our concurrents on this market, the 1.0000000000000001 wasn't rounded to 1 despite the setting of \xintDigits; it would have been if we had input it as (1+1e-15).

### 30.11 \xintifboolexpr

*xnn* ★ \xintifboolexpr{<expr>}{YES}{NO} does \xinttheexpr <expr>\relax and then executes the YES or the NO branch depending on whether the outcome was non-zero or zero. <expr> can involve various & and |, parentheses, all, any, xor, the bool or tog1 operators, but is not limited to them: the most general computation can be done, the test is on whether the outcome of the computation vanishes or not.

Will not work on an expression composed of comma separated sub-expressions.

### 30.12 \xintifboolfloatexpr

*xnn* ★ \xintifboolfloatexpr{<expr>}{YES}{NO} does \xintthefloatexpr <expr>\relax and then executes the YES or the NO branch depending on whether the outcome was non zero or zero.

### 30.13 \xintifbooliiexpr

*xnn* ★ \xintifbooliiexpr{<expr>}{YES}{NO} does \xinttheiiexpr <expr>\relax and then executes the YES or the NO branch depending on whether the outcome was non zero or zero.

### 30.14 \xintNewFloatExpr

This is exactly like \xintNewExpr except that the created formulas are set-up to use \xintthefloatexpr. The precision used for numbers fetched as parameters will be the one locally given by \xintDigits at the time of use of the created formulas, not \xintNewFloatExpr. However, the numbers hard-wired in the original expression will have been evaluated with the then current setting for \xintDigits.

### 30.15 \xintNewIExpr

Like \xintNewExpr but using \xinttheiexpr. Former denomination was \xintNewNumExpr which is deprecated and should not be used.

### 30.16 \xintNewIIExpr

Like \xintNewExpr but using \xinttheiiexpr.

### 30.17 \xintNewBoolExpr

Like \xintNewExpr but using \xinttheboolexpr.

### 30.18 Technicalities

As already mentioned `\xintNewExpr\myformula[n]` does not check the prior existence of a macro `\myformula`. And the number of parameters `n` given as mandatory argument withing square brackets should be (at least) equal to the number of parameters in the expression.

Obviously I should mention that `\xintNewExpr` itself can not be used in an expansion-only context, as it creates a macro.

The `\escapechar` setting may be arbitrary when using `\xintexpr`.

Changed! → The format of the output of `\xintexpr<stuff>\relax` is a `!` (with catcode 11) followed by `\XINT_expr_usethe` which prints an error message in the document and in the log file if it is executed, then a `\xint_protect` token, a token doing the actual printing and finally a token `\.=A/B[n]`. Using `\xinttheexpr` means zapping the first three things, the fourth one will then unlock `A/B[n]` from the (presumably undefined, but it does not matter) control sequence `\.=A/B[n]`.

Thanks to the release 1.09j added `\xint_protect` token and the fact that `\XINT_expr_usethe` is `\protected`, one can now use `\xintexpr` inside an `\edef`, with no need of the `\xint-` prefix.

New! → Note that `\xintexpr` is thus compatible to complete expansion, contrarily to `\numexpr` which is non-expandable if not prefixed by `\the`. See [subsection 27.22](#) for some illustration.

I decided to put all intermediate results (from each evaluation of an infix operators, or of a parenthesized subpart of the expression, or from application of the minus as prefix, or of the exclamation sign as postfix, or any encountered braced material) inside `\csname...` `\endcsname`, as this can be done expandably and encapsulates an arbitrarily long fraction in a single token (left with undefined meaning), thus providing tremendous relief to the programmer in his/her expansion control.

As the `\xintexpr` computations corresponding to functions and infix or postfix operators are done inside `\csname...` `\endcsname`, the *f*-expandability could possibly be dropped and one could imagine implementing the basic operations with expandable but not *f*-expandable macros (as `\xintXTrunc`.) I have not investigated that possibility.

Syntax errors in the input such as using a one-argument function with two arguments will generate low-level TeX processing unrecoverable errors, with cryptic accompanying message.

Some other problems will give rise to ‘error messages’ macros giving some indication on the location and nature of the problem. Mainly, an attempt has been made to handle gracefully missing or extraneous parentheses.

When the scanner is looking for a number and finds something else not otherwise treated, it assumes it is the start of the function name and will expand forward in the hope of hitting an opening parenthesis; if none is found at least it should stop when encountering the `\relax` marking the end of the expressions.

Note that `\relax` is mandatory (contrarily to a `\numexpr`).

### 30.19 Acknowledgements

I was greatly helped in my preparatory thinking, prior to producing such an expandable parser, by the commented source of the **l3fp** package, specifically the `l3fp-parse.dtx` file. Also the source of the `calc` package was instructive, despite the fact that here for `\xintexpr` the principles are necessarily different due to the aim of achieving expandability.

## 31 Commands of the **xintbinhex** package

This package was first included in the 1.08 release of **xint**. It provides expandable conversions of arbitrarily long numbers to and from binary and hexadecimal.

The argument is first *f*-expanded. It then may start with an optional minus sign (unique, of category code other), followed with optional leading zeros (arbitrarily many, category code other) and then “digits” (hexadecimal letters may be of category code letter or other, and must be uppercased). The optional (unique) minus sign (plus sign is not allowed) is kept in the output. Leading zeros are allowed, and stripped. The hexadecimal letters on output are of category code letter, and uppercased.

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#### 31.1 `\xintDecToHex`

*f* ★ Converts from decimal to hexadecimal.

```
\xintDecToHex{2718281828459045235360287471352662497757247093699959574
966967627724076630353547594571382178525166427427466391932003}
->11A9397C66949A97051F7D0A817914E3E0B17C41B11C48BAEF2B5760BB38D272F4
6DCE46C6032936BF37DAC918814C63
```

#### 31.2 `\xintDecToBin`

*f* ★ Converts from decimal to binary.

```
\xintDecToBin{2718281828459045235360287471352662497757247093699959574
966967627724076630353547594571382178525166427427466391932003}
->100011010100100111001011111000110011010010100100110101001011100000
10100011111011111010000101010000001011110010001010011100011111000001
01100010111110001000001101100010001110001001000101110101110111100101
01101010111011000001011101100111000110100100111001011110100011011011
10011100100011011000110000000110010100100110110101111110011011111011
0101100100100011000100000010100110001100011
```

### 31.3 `\xintHexToDec`

*f* ★ Converts from hexadecimal to decimal.

```
\xintHexToDec{11A9397C66949A97051F7D0A817914E3E0B17C41B11C48BAEF2B576
0BB38D272F46DCE46C6032936BF37DAC918814C63}
->271828182845904523536028747135266249775724709369995957496696762772
4076630353547594571382178525166427427466391932003
```

### 31.4 `\xintBinToDec`

*f* ★ Converts from binary to decimal.

```
\xintBinToDec{1000110101001001110010111110001100110100101001001101010
0101110000001010001111101111101000001010100000010111100100010100111000111
1100000010110001011111000100000011011000100011100010010001011101011101111
001010110101011101100000010111011001110001101001001110010111101000110110
11100111001000110110001100000000110010100100110110101111100110111110110
1011001001000110001000000010100110001100011}
->271828182845904523536028747135266249775724709369995957496696762772
4076630353547594571382178525166427427466391932003
```

### 31.5 `\xintBinToHex`

*f* ★ Converts from binary to hexadecimal.

```
\xintBinToHex{1000110101001001110010111110001100110100101001001101010
0101110000001010001111101111101000001010100000010111100100010100111000111
1100000010110001011111000100000011011000100011100010010001011101011101111
001010110101011101100000010111011001110001101001001110010111101000110110
111001110010001101100011000000001100101001001101101011111100110111110110
1011001001000110001000000010100110001100011}
->11A9397C66949A97051F7D0A817914E3E0B17C41B11C48BAEF2B5760BB38D272F4
6DCE46C6032936BF37DAC918814C63
```

### 31.6 `\xintHexToBin`

*f* ★ Converts from hexadecimal to binary.

```
\xintHexToBin{11A9397C66949A97051F7D0A817914E3E0B17C41B11C48BAEF2B576
0BB38D272F46DCE46C6032936BF37DAC918814C63}
->100011010100100111001011111000110011010010100100110101001011100000
101000111110111110100000101010000001011110010001010011100011111000001
011000101111100010000001101100010001110001001000101110101110111100101
011010101110110000001011101100111000110100100111001011110100011011011
100111001000110110001100000000110010100100110110101111110011011111011
01011001001000110001000000010100110001100011
```

### 31.7 `\xintCHexToBin`

*f* ★ Also converts from hexadecimal to binary. Faster on inputs with at least one hundred hexadecimal digits.

```
\xintCHexToBin{11A9397C66949A97051F7D0A817914E3E0B17C41B11C48BAEF2B57
60BB38D272F46DCE46C6032936BF37DAC918814C63}
->100011010100100111001011111000110011010010100100110101001011100000
10100011111011111010000101010000001011110010001010011100011111000001
01100010111110001000001101100010001110001001000101110101110111100101
01101010111011000001011101100111000110100100111001011110100011011011
10011100100011011000110000000110010100100110110101111110011011111011
0101100100100011000100000010100110001100011
```

## 32 Commands of the **xintgcd** package

This package was included in the original release 1.0 of the **xint** bundle.

Since release 1.09a the macros filter their inputs through the `\xintNum` macro, so one can use count registers, or fractions as long as they reduce to integers.

### Contents

.1	<code>\xintGCD</code> .....	108	.6	<code>\xintEuclideanAlgorithm</code> .....	109
.2	<code>\xintGCDof</code> .....	108	.7	<code>\xintBezoutAlgorithm</code> .....	109
.3	<code>\xintLCM</code> .....	108	.8	<code>\xintTypesetEuclideanAlgorithm</code>	
.4	<code>\xintLCMof</code> .....	108		.....	109
.5	<code>\xintBezout</code> .....	109	.9	<code>\xintTypesetBezoutAlgorithm</code>	110

#### 32.1 `\xintGCD`

$\overset{\text{Num}}{f} \overset{\text{Num}}{f} \star$

`\xintGCD{N}{M}` computes the greatest common divisor. It is positive, except when both N and M vanish, in which case the macro returns zero.

```
\xintGCD{10000}{1113}=1
\xintGCD{123456789012345}{9876543210321}=3
```

#### 32.2 `\xintGCDof`

$f \rightarrow * \overset{\text{Num}}{f} \star$

`\xintGCDof{{a}{b}{c}...}` computes the greatest common divisor of all integers a, b, ... The list argument may be a macro, it is *f*-expanded first and must contain at least one item.

#### 32.3 `\xintLCM`

$\overset{\text{Num}}{f} \overset{\text{Num}}{f} \star$

`\xintGCD{N}{M}` computes the least common multiple. It is 0 if one of the two integers vanishes.

#### 32.4 `\xintLCMof`

$f \rightarrow * \overset{\text{Num}}{f} \star$

`\xintLCMof{{a}{b}{c}...}` computes the least common multiple of all integers a, b, ... The list argument may be a macro, it is *f*-expanded first and must contain at least one item.

**32.5 \xintBezout**Num Num  
f f ★

`\xintBezout{N}{M}` returns five numbers A, B, U, V, D within braces. A is the first (expanded, as usual) input number, B the second, D is the GCD, and  $UA - VB = D$ .

```

\xintAssign {\xintBezout {10000}{1113}}\to\X
\meaning\X: macro:->\xintBezout {10000}{1113}.
\xintAssign {\xintBezout {10000}{1113}}\to\A\B\U\V\D
\A: 10000, \B: 1113, \U: -131, \V: -1177, \D: 1.
\xintAssign {\xintBezout {123456789012345}{9876543210321}}\to\A\B\U\V\D
\A: 123456789012345, \B: 9876543210321, \U: 256654313730, \V: 3208178892607,
\D: 3.

```

**32.6 \xintEuclideanAlgorithm**Num Num  
f f ★

`\xintEuclideanAlgorithm{N}{M}` applies the Euclidean algorithm and keeps a copy of all quotients and remainders.

```

\xintAssign {\xintEuclideanAlgorithm {10000}{1113}}\to\X
\meaning\X: macro:->\xintEuclideanAlgorithm {10000}{1113}.

```

The first token is the number of steps, the second is N, the third is the GCD, the fourth is M then the first quotient and remainder, the second quotient and remainder, ... until the final quotient and last (zero) remainder.

**32.7 \xintBezoutAlgorithm**Num Num  
f f ★

`\xintBezoutAlgorithm{N}{M}` applies the Euclidean algorithm and keeps a copy of all quotients and remainders. Furthermore it computes the entries of the successive products of the 2 by 2 matrices  $\begin{pmatrix} q & 1 \\ 1 & 0 \end{pmatrix}$  formed from the quotients arising in the algorithm.

```

\xintAssign {\xintEuclideanAlgorithm {10000}{1113}}\to\X
\meaning\X: macro:->\xintBezoutAlgorithm {10000}{1113}.

```

The first token is the number of steps, the second is N, then 0, 1, the GCD, M, 1, 0, the first quotient, the first remainder, the top left entry of the first matrix, the bottom left entry, and then these four things at each step until the end.

**32.8 \xintTypesetEuclideanAlgorithm**Num Num  
f f

This macro is just an example of how to organize the data returned by `\xintEuclideanAlgorithm`. Copy the source code to a new macro and modify it to what is needed.

```

\xintTypesetEuclideanAlgorithm {123456789012345}{9876543210321}
123456789012345 = 12 × 9876543210321 + 4938270488493
9876543210321 = 2 × 4938270488493 + 2233335
4938270488493 = 2211164 × 2233335 + 536553
2233335 = 4 × 536553 + 87123
536553 = 6 × 87123 + 13815
87123 = 6 × 13815 + 4233
13815 = 3 × 4233 + 1116
4233 = 3 × 1116 + 885
1116 = 1 × 885 + 231

```

$$\begin{aligned}
885 &= 3 \times 231 + 192 \\
231 &= 1 \times 192 + 39 \\
192 &= 4 \times 39 + 36 \\
39 &= 1 \times 36 + 3 \\
36 &= 12 \times 3 + 0
\end{aligned}$$

### 32.9 `\xintTypesetBezoutAlgorithm`

$\overset{\text{Num}}{f} \overset{\text{Num}}{f}$

This macro is just an example of how to organize the data returned by `\xintBezoutAlgorithm`. Copy the source code to a new macro and modify it to what is needed.

```

\xintTypesetBezoutAlgorithm {10000}{1113}
10000 = 8 \times 1113 + 1096
8 = 8 \times 1 + 0
1 = 8 \times 0 + 1
1113 = 1 \times 1096 + 17
9 = 1 \times 8 + 1
1 = 1 \times 1 + 0
1096 = 64 \times 17 + 8
584 = 64 \times 9 + 8
65 = 64 \times 1 + 1
17 = 2 \times 8 + 1
1177 = 2 \times 584 + 9
131 = 2 \times 65 + 1
8 = 8 \times 1 + 0
10000 = 8 \times 1177 + 584
1113 = 8 \times 131 + 65
131 \times 10000 - 1177 \times 1113 = -1

```

## 33 Commands of the **xintseries** package

Some arguments to the package commands are macros which are expanded only later, when given their parameters. The arguments serving as indices are systematically given to a `\numexpr` expressions (new with 1.06!), hence  $f$ -expanded, they may be count registers, etc...

This package was first released with version 1.03 of the **xint** bundle.

We use  $\overset{\text{Frac}}{f}$  for the expansion type of various macro arguments, but if only **xint** and not **xintfrac** is loaded this should be more appropriately  $\overset{\text{Num}}{f}$ . The macro `\xintiSeries` is special and expects summing big integers obeying the strict format, even if **xintfrac** is loaded.

## Contents

.1	<code>\xintSeries</code> .....	111	.4	<code>\xintRationalSeriesX</code> .....	116
.2	<code>\xintiSeries</code> .....	112	.5	<code>\xintPowerSeries</code> .....	118
.3	<code>\xintRationalSeries</code> .....	113	.6	<code>\xintPowerSeriesX</code> .....	120

.7	<code>\xintFxpPowerSeries</code> .....	120	.9	<code>\xintFloatPowerSeries</code> .....	123
.8	<code>\xintFxpPowerSeriesX</code> .....	121	.10	<code>\xintFloatPowerSeriesX</code> .....	123
			.11	Computing $\log 2$ and $\pi$ .....	123

### 33.1 `\xintSeries`

$\frac{\text{num}}{x} \frac{\text{num}}{x} \frac{\text{Frac}}{f}$  ★

`\xintSeries{A}{B}{\coeff}` computes  $\sum_{n=A}^{n=B} \text{coeff}\{n\}$ . The initial and final indices must obey the `\numexpr` constraint of expanding to numbers at most  $2^{31}-1$ . The `\coeff` macro must be a one-parameter *f*-expandable command, taking on input an explicit number *n* and producing some number or fraction `\coeff{n}`; it is expanded at the time it is needed.<sup>65</sup>

```
\def\coeff #1{\xintiMON{#1}/#1.5} % (-1)^n/(n+1/2)
\edef\w {\xintSeries {0}{50}{\coeff}} % we want to re-use it
\edef\z {\xintJrr {\w}[0]} % the [0] for a microsecond gain.
% \xintJrr preferred to \xintIrr: a big common factor is suspected.
% But numbers much bigger would be needed to show the greater efficiency.
\[ \sum_{n=0}^{50} (-1)^n = \frac{173909338287370940432112792101626602278714}{110027467159390003025279917226039729050575}
```

$$\sum_{n=0}^{50} \frac{(-1)^n}{n + \frac{1}{2}} = \frac{173909338287370940432112792101626602278714}{110027467159390003025279917226039729050575}$$

For info, before action by `\xintJrr` the inner representation of the result has a denominator of `\xintLen {\xintDenominator\w}=117` digits. This troubled me as  $101!!$  has only 81 digits: `\xintLen {\xintQuo {\xintFac {101}}{\xintiMul {\xintiPow {2}{50}}{\xintFac{50}}}}=81`. The explanation lies in the too clever to be efficient #1.5 trick. It leads to a silly extra  $5^{51}$  (which has 36 digits) in the denominator. See the explanations in the next section.

Note: as soon as the coefficients look like factorials, it is more efficient to use the `\xintRationalSeries` macro whose evaluation will avoid a denominator build-up; indeed the raw operations of addition and subtraction of fractions blindly multiply out denominators. So the raw evaluation of  $\sum_{n=0}^N 1/n!$  with `\xintSeries` will have a denominator equal to  $\prod_{n=0}^N n!$ . Needless to say this makes it more difficult to compute the exact value of this sum with  $N=50$ , for example, whereas with `\xintRationalSeries` the denominator does not get bigger than  $50!$ .

For info: by the way  $\prod_{n=0}^{50} n!$  is easily computed by **xint** and is a number with 1394 digits. And  $\prod_{n=0}^{100} n!$  is also computable by **xint** (24 seconds on my laptop for the brute force iterated multiplication of all factorials, a specialized routine would do it faster) and has 6941 digits (this means more than two pages if printed...). Whereas  $100!$  only has 158 digits.

```
\def\coeffleibnitz #1{\the\numexpr\ifodd #1 1\else-1\fi\relax/#1[0]}
\cnta 1
\loop % in this loop we recompute from scratch each partial sum!
% we can afford that, as \xintSeries is fast enough.
\noindent\hbox to 2em{\hfil\texttt{\the\cnta.} }%
```

<sup>65</sup> `\xintiMON` is like `\xintMON` but does not parse its argument through `\xintNum`, for efficiency; other macros of this type are `\xintiAdd`, `\xintiMul`, `\xintiSum`, `\xintiPrd`, `\xintiMMON`, `\xintiLDg`, `\xintiFDg`, `\xintiOdd`, ...

```

\mintTrunc {12}
\mintSeries {1}{\cnta}{\coeffleibnitz}}\dots
\endgraf
\ifnum\cnta < 30 \advance\cnta 1 \repeat

1. 1.000000000000...    11. 0.736544011544...    21. 0.716390450794...
2. 0.500000000000...    12. 0.653210678210...    22. 0.670935905339...
3. 0.833333333333...    13. 0.730133755133...    23. 0.714414166209...
4. 0.583333333333...    14. 0.658705183705...    24. 0.672747499542...
5. 0.783333333333...    15. 0.725371850371...    25. 0.712747499542...
6. 0.616666666666...    16. 0.662871850371...    26. 0.674285961081...
7. 0.759523809523...    17. 0.721695379783...    27. 0.711322998118...
8. 0.634523809523...    18. 0.666139824228...    28. 0.675608712404...
9. 0.745634920634...    19. 0.718771403175...    29. 0.710091471024...
10. 0.645634920634...   20. 0.668771403175...    30. 0.676758137691...

```

### 33.2 \xintiSeries

$\sum_{n=A}^B f(x)$  ★

`\xintiSeries{A}{B}{\coeff}` computes  $\sum_{n=A}^B \coeff{n}$  where `\coeff{n}` must *f*-expand to a (possibly long) integer in the strict format.

```

\def\coeff #1{\mintTrunc {40}{\mintMON{#1}/#1.5}}%
% better:
\def\coeff #1{\mintTrunc {40}
  {\the\numexpr 2*\mintiiMON{#1}\relax/\the\numexpr 2*#1+1\relax [0]}}%
% better still:
\def\coeff #1{\mintTrunc {40}
  {\the\numexpr \ifodd #1 -2\else 2\fi\relax/\the\numexpr 2*#1+1\relax [0]}}%
% (-1)^n/(n+1/2) times 10^40, truncated to an integer.
\[\sum_{n=0}^{50} \frac{(-1)^n}{n+\frac{1}{2}} \approx
  \mintTrunc {40}{\mintSeries {0}{50}{\coeff}[-40]}\dots\]

```

The #1.5 trick to define the `\coeff` macro was neat, but 1/3.5, for example, turns internally into 10/35 whereas it would be more efficient to have 2/7. The second way of coding the wanted coefficient avoids a superfluous factor of five and leads to a faster evaluation. The third way is faster, after all there is no need to use `\mintMON` (or rather `\mintiiMON` which has less parsing overhead) on integers obeying the  $\text{\TeX}$  bound. The denominator having no sign, we have added the `[0]` as this speeds up (infinitesimally) the parsing.

$$\sum_{n=0}^{50} \frac{(-1)^n}{n + \frac{1}{2}} \approx 1.5805993064935250412367895069567264144810$$

We should have cut out at least the last two digits: truncating errors originating with the first coefficients of the sum will never go away, and each truncation introduces an uncertainty in the last digit, so as we have 40 terms, we should trash the last two digits, or at least round at 38 digits. It is interesting to compare with the computation where rounding rather than truncation is used, and with the decimal expansion of the exactly computed partial sum of the series:

```

\def\coeff #1{\mintRound {40} % rounding at 40

```

```

{\the\numexpr\ifodd #1 -2\else2\fi\relax/\the\numexpr 2*#1+1\relax [0]}}%
% (-1)^n/(n+1/2) times 10^40, rounded to an integer.
\[ \sum_{n=0}^{n=50} \frac{(-1)^n}{n+\frac{1}{2}} \approx
    \xintTrunc {40}{\xintiSeries {0}{50}{\coeff}{-40}}\]
\def\exactcoeff #1%
{\the\numexpr\ifodd #1 -2\else2\fi\relax/\the\numexpr 2*#1+1\relax [0]}}%
\[ \sum_{n=0}^{n=50} \frac{(-1)^n}{n+\frac{1}{2}}
    = \xintTrunc {50}{\xintiSeries {0}{50}{\exactcoeff}}\dots\]

```

$$\sum_{n=0}^{n=50} \frac{(-1)^n}{n + \frac{1}{2}} \approx 1.5805993064935250412367895069567264144804$$

$$\sum_{n=0}^{n=50} \frac{(-1)^n}{n + \frac{1}{2}} = 1.58059930649352504123678950695672641448068680288367 \dots$$

This shows indeed that our sum of truncated terms estimated wrongly the 39th and 40th digits of the exact result<sup>66</sup> and that the sum of rounded terms fared a bit better.

### 33.3 `\xintRationalSeries`

`\xintRationalSeries{A}{B}{f}{\ratio}` evaluates  $\sum_{n=A}^{n=B} F(n)$ , where  $F(n)$  is specified indirectly via the data of  $f=F(A)$  and the one-parameter macro `\ratio` which must be such that `\macro{n}` expands to  $F(n)/F(n-1)$ . The name indicates that `\xintRationalSeries` was designed to be useful in the cases where  $F(n)/F(n-1)$  is a rational function of  $n$  but it may be anything expanding to a fraction. The macro `\ratio` must be an expandable-only compatible command and expand to its value after iterated full expansion of its first token.  $A$  and  $B$  are fed to a `\numexpr` hence may be count registers or arithmetic expressions built with such; they must obey the  $\TeX$  bound. The initial term  $f$  may be a macro `\f`, it will be expanded to its value representing  $F(A)$ .

```

\def\ratio #1{2/#1[0]}}% 2/n, to compute exp(2)
\cnta 0 % previously declared count
\loop \edef\z {\xintRationalSeries {0}{\cnta}{1}{\ratio }}%
\noindent$\sum_{n=0}^{\the\cnta} \frac{2^n}{n!}=
    \xintTrunc{12}{\z}\dots=
    \xintFrac\z=\xintFrac{\xintIrr\z}{\vtop to 5pt}\endgraf
\ifnum\cnta<20 \advance\cnta 1 \repeat

$$\sum_{n=0}^0 \frac{2^n}{n!} = 1.000000000000 \dots = 1 = 1$$


$$\sum_{n=0}^1 \frac{2^n}{n!} = 3.000000000000 \dots = 3 = 3$$


$$\sum_{n=0}^2 \frac{2^n}{n!} = 5.000000000000 \dots = \frac{10}{2} = 5$$


$$\sum_{n=0}^3 \frac{2^n}{n!} = 6.333333333333 \dots = \frac{38}{6} = \frac{19}{3}$$


$$\sum_{n=0}^4 \frac{2^n}{n!} = 7.000000000000 \dots = \frac{168}{24} = 7$$


$$\sum_{n=0}^5 \frac{2^n}{n!} = 7.266666666666 \dots = \frac{872}{120} = \frac{109}{15}$$


$$\sum_{n=0}^6 \frac{2^n}{n!} = 7.355555555555 \dots = \frac{5296}{720} = \frac{331}{45}$$


$$\sum_{n=0}^7 \frac{2^n}{n!} = 7.380952380952 \dots = \frac{37200}{5040} = \frac{155}{21}$$


$$\sum_{n=0}^8 \frac{2^n}{n!} = 7.387301587301 \dots = \frac{297856}{40320} = \frac{2327}{315}$$


```

<sup>66</sup> as the series is alternating, we can roughly expect an error of  $\sqrt{40}$  and the last two digits are off by 4 units, which is not contradictory to our expectations.

$$\begin{aligned}
\sum_{n=0}^9 \frac{2^n}{n!} &= 7.388712522045 \dots = \frac{2681216}{362880} = \frac{20947}{2835} \\
\sum_{n=0}^{10} \frac{2^n}{n!} &= 7.388994708994 \dots = \frac{26813184}{3628800} = \frac{34913}{4725} \\
\sum_{n=0}^{11} \frac{2^n}{n!} &= 7.389046015712 \dots = \frac{294947072}{39916800} = \frac{164591}{22275} \\
\sum_{n=0}^{12} \frac{2^n}{n!} &= 7.389054566832 \dots = \frac{3539368960}{479001600} = \frac{691283}{93555} \\
\sum_{n=0}^{13} \frac{2^n}{n!} &= 7.389055882389 \dots = \frac{46011804672}{6227020800} = \frac{14977801}{2027025} \\
\sum_{n=0}^{14} \frac{2^n}{n!} &= 7.389056070325 \dots = \frac{644165281792}{87178291200} = \frac{314533829}{42567525} \\
\sum_{n=0}^{15} \frac{2^n}{n!} &= 7.389056095384 \dots = \frac{9662479259648}{1307674368000} = \frac{4718007451}{638512875} \\
\sum_{n=0}^{16} \frac{2^n}{n!} &= 7.389056098516 \dots = \frac{154599668219904}{20922789888000} = \frac{1572669151}{212837625} \\
\sum_{n=0}^{17} \frac{2^n}{n!} &= 7.389056098884 \dots = \frac{2628194359869440}{355687428096000} = \frac{16041225341}{2170943775} \\
\sum_{n=0}^{18} \frac{2^n}{n!} &= 7.389056098925 \dots = \frac{47307498477912064}{6402373705728000} = \frac{103122162907}{13956067125} \\
\sum_{n=0}^{19} \frac{2^n}{n!} &= 7.389056098930 \dots = \frac{898842471080853504}{121645100408832000} = \frac{4571749222213}{618718975875} \\
\sum_{n=0}^{20} \frac{2^n}{n!} &= 7.389056098930 \dots = \frac{17976849421618118656}{2432902008176640000} = \frac{68576238333199}{9280784638125}
\end{aligned}$$

Such computations would become quickly completely inaccessible via the `\xintSeries` macros, as the factorials in the denominators would get all multiplied together: the raw addition and subtraction on fractions just blindly multiplies denominators! Whereas `\xintRationalSeries` evaluate the partial sums via a less silly iterative scheme.

```

\def\ratio #1{-1/#1[0]}% -1/n, comes from the series of exp(-1)
\cnta 0 % previously declared count
\loop
\edef\z {\xintRationalSeries {0}{\cnta}{1}{\ratio }}%
\noindent$\sum_{n=0}^{\the\cnta} \frac{(-1)^n}{n!}=
\xintTrunc{20}\z\dots=\xintFrac{\z}=\xintFrac{\xintIrr\z}$
\vtop to 5pt{}\endgraf

\ifnum\cnta<20 \advance\cnta 1 \repeat

$$\begin{aligned}
\sum_{n=0}^0 \frac{(-1)^n}{n!} &= 1.00000000000000000000 \dots = 1 = 1 \\
\sum_{n=0}^1 \frac{(-1)^n}{n!} &= 0 \dots = 0 = 0 \\
\sum_{n=0}^2 \frac{(-1)^n}{n!} &= 0.50000000000000000000 \dots = \frac{1}{2} = \frac{1}{2} \\
\sum_{n=0}^3 \frac{(-1)^n}{n!} &= 0.33333333333333333333 \dots = \frac{2}{6} = \frac{1}{3} \\
\sum_{n=0}^4 \frac{(-1)^n}{n!} &= 0.37500000000000000000 \dots = \frac{9}{24} = \frac{3}{8} \\
\sum_{n=0}^5 \frac{(-1)^n}{n!} &= 0.36666666666666666666 \dots = \frac{44}{120} = \frac{11}{30} \\
\sum_{n=0}^6 \frac{(-1)^n}{n!} &= 0.36805555555555555555 \dots = \frac{265}{720} = \frac{53}{144} \\
\sum_{n=0}^7 \frac{(-1)^n}{n!} &= 0.36785714285714285714 \dots = \frac{1854}{5040} = \frac{103}{280} \\
\sum_{n=0}^8 \frac{(-1)^n}{n!} &= 0.36788194444444444444 \dots = \frac{14833}{40320} = \frac{2119}{5760} \\
\sum_{n=0}^9 \frac{(-1)^n}{n!} &= 0.36787918871252204585 \dots = \frac{133496}{362880} = \frac{16687}{45360} \\
\sum_{n=0}^{10} \frac{(-1)^n}{n!} &= 0.36787946428571428571 \dots = \frac{1334961}{3628800} = \frac{16481}{44800} \\
\sum_{n=0}^{11} \frac{(-1)^n}{n!} &= 0.36787943923360590027 \dots = \frac{14684570}{39916800} = \frac{1468457}{3991680} \\
\sum_{n=0}^{12} \frac{(-1)^n}{n!} &= 0.36787944132128159905 \dots = \frac{176214841}{479001600} = \frac{16019531}{43545600} \\
\sum_{n=0}^{13} \frac{(-1)^n}{n!} &= 0.36787944116069116069 \dots = \frac{2290792932}{6227020800} = \frac{63633137}{172972800} \\
\sum_{n=0}^{14} \frac{(-1)^n}{n!} &= 0.36787944117216190628 \dots = \frac{32071101049}{87178291200} = \frac{2467007773}{6706022400} \\
\sum_{n=0}^{15} \frac{(-1)^n}{n!} &= 0.36787944117139718991 \dots = \frac{481066515734}{1307674368000} = \frac{34361893981}{93405312000} \\
\sum_{n=0}^{16} \frac{(-1)^n}{n!} &= 0.36787944117144498468 \dots = \frac{7697064251745}{20922789888000} = \frac{15549624751}{42268262400}
\end{aligned}$$


```

$$\begin{aligned} \sum_{n=0}^{17} \frac{(-1)^n}{n!} &= 0.36787944117144217323 \dots = \frac{130850092279664}{355687428096000} = \frac{8178130767479}{22230464256000} \\ \sum_{n=0}^{18} \frac{(-1)^n}{n!} &= 0.36787944117144232942 \dots = \frac{2355301661033953}{6402373705728000} = \frac{138547156531409}{376610217984000} \\ \sum_{n=0}^{19} \frac{(-1)^n}{n!} &= 0.36787944117144232120 \dots = \frac{44750731559645106}{121645100408832000} = \frac{92079694567171}{250298665120000} \\ \sum_{n=0}^{20} \frac{(-1)^n}{n!} &= 0.36787944117144232161 \dots = \frac{895014631192902121}{2432902008176640000} = \frac{428236665425369}{116406794649600000} \end{aligned}$$

We can incorporate an indeterminate if we define `\ratio` to be a macro with two parameters: `\def\ratioexp #1#2{\xintDiv{#1}{#2}}% x/n: x=#1, n=#2`. Then, if `\x` expands to some fraction `x`, the command

```
\xintRationalSeries {0}{b}{1}\ratioexp{x}
will compute \sum_{n=0}^{n=b} x^n/n!:
\cnta 0
\def\ratioexp #1#2{\xintDiv{#1}{#2}}% #1/#2
\loop
\noindent
$\sum_{n=0}^{\the\cnta} (.57)^n/n! = \xintTrunc {50}
    {\xintRationalSeries {0}{\cnta}{1}\ratioexp{.57}}\dots$
    \vtop to 5pt {} \endgraf
\ifnum\cnta<50 \advance\cnta 10 \repeat
```

$$\begin{aligned} \sum_{n=0}^0 (.57)^n/n! &= 1.00 \\ \sum_{n=0}^{10} (.57)^n/n! &= 1.76826705137947002480668058035714285714285714285 \\ \sum_{n=0}^{20} (.57)^n/n! &= 1.76826705143373515162089324271187082272833005529 \\ \sum_{n=0}^{30} (.57)^n/n! &= 1.76826705143373515162089339282382144915484884979 \\ \sum_{n=0}^{40} (.57)^n/n! &= 1.76826705143373515162089339282382144915485219867 \\ \sum_{n=0}^{50} (.57)^n/n! &= 1.76826705143373515162089339282382144915485219867 \end{aligned}$$

Observe that in this last example the `x` was directly inserted; if it had been a more complicated explicit fraction it would have been worthwhile to use `\ratioexp\x` with `\x` defined to expand to its value. In the further situation where this fraction `x` is not explicit but itself defined via a complicated, and time-costly, formula, it should be noted that `\xintRationalSeries` will do again the evaluation of `\x` for each term of the partial sum. The easiest is thus when `x` can be defined as an `\edef`. If however, you are in an expandable-only context and cannot store in a macro like `\x` the value to be used, a variant of `\xintRationalSeries` is needed which will first evaluate this `\x` and then use this result without recomputing it. This is `\xintRationalSeriesX`, documented next.

Here is a slightly more complicated evaluation:

```

\cnta 1
\loop \edef\z {\xintRationalSeries
      {\cnta}
      {2*\cnta-1}
      {\xintiPow {\the\cnta}{\cnta}/\xintFac{\cnta}}
      {\ratioexp{\the\cnta}}}%
\edef\w {\xintRationalSeries {0}{2*\cnta-1}{1}{\ratioexp{\the\cnta}}}%
\noindent

$$\sum_{n=\text{the}\cnta}^{\text{the}\numexpr 2*\cnta-1\relax} \frac{\text{the}\cnta^n \{n!\}}{\sum_{n=0}^{\text{the}\numexpr 2*\cnta-1\relax} \frac{\text{the}\cnta^n \{n!\}}{\xintTrunc{8}{\xintDiv{\z}{\w}}\dots} \text{vtop to 5pt}} =$$

\ifnum\cnta<20 \advance\cnta 1 \repeat

```

$$\begin{array}{ll}
\sum_{n=1}^1 \frac{1^n}{n!} / \sum_{n=0}^1 \frac{1^n}{n!} = 0.50000000 \dots & \sum_{n=11}^{21} \frac{11^n}{n!} / \sum_{n=0}^{21} \frac{11^n}{n!} = 0.53907332 \dots \\
\sum_{n=2}^3 \frac{2^n}{n!} / \sum_{n=0}^3 \frac{2^n}{n!} = 0.52631578 \dots & \sum_{n=12}^{23} \frac{12^n}{n!} / \sum_{n=0}^{23} \frac{12^n}{n!} = 0.53772178 \dots \\
\sum_{n=3}^5 \frac{3^n}{n!} / \sum_{n=0}^5 \frac{3^n}{n!} = 0.53804347 \dots & \sum_{n=13}^{25} \frac{13^n}{n!} / \sum_{n=0}^{25} \frac{13^n}{n!} = 0.53644744 \dots \\
\sum_{n=4}^7 \frac{4^n}{n!} / \sum_{n=0}^7 \frac{4^n}{n!} = 0.54317053 \dots & \sum_{n=14}^{27} \frac{14^n}{n!} / \sum_{n=0}^{27} \frac{14^n}{n!} = 0.53525726 \dots \\
\sum_{n=5}^9 \frac{5^n}{n!} / \sum_{n=0}^9 \frac{5^n}{n!} = 0.54502576 \dots & \sum_{n=15}^{29} \frac{15^n}{n!} / \sum_{n=0}^{29} \frac{15^n}{n!} = 0.53415135 \dots \\
\sum_{n=6}^{11} \frac{6^n}{n!} / \sum_{n=0}^{11} \frac{6^n}{n!} = 0.54518217 \dots & \sum_{n=16}^{31} \frac{16^n}{n!} / \sum_{n=0}^{31} \frac{16^n}{n!} = 0.53312615 \dots \\
\sum_{n=7}^{13} \frac{7^n}{n!} / \sum_{n=0}^{13} \frac{7^n}{n!} = 0.54445274 \dots & \sum_{n=17}^{33} \frac{17^n}{n!} / \sum_{n=0}^{33} \frac{17^n}{n!} = 0.53217628 \dots \\
\sum_{n=8}^{15} \frac{8^n}{n!} / \sum_{n=0}^{15} \frac{8^n}{n!} = 0.54327992 \dots & \sum_{n=18}^{35} \frac{18^n}{n!} / \sum_{n=0}^{35} \frac{18^n}{n!} = 0.53129566 \dots \\
\sum_{n=9}^{17} \frac{9^n}{n!} / \sum_{n=0}^{17} \frac{9^n}{n!} = 0.54191055 \dots & \sum_{n=19}^{37} \frac{19^n}{n!} / \sum_{n=0}^{37} \frac{19^n}{n!} = 0.53047810 \dots \\
\sum_{n=10}^{19} \frac{10^n}{n!} / \sum_{n=0}^{19} \frac{10^n}{n!} = 0.54048295 \dots & \sum_{n=20}^{39} \frac{20^n}{n!} / \sum_{n=0}^{39} \frac{20^n}{n!} = 0.52971771 \dots
\end{array}$$

### 33.4 \xintRationalSeriesX

num num Frac Frac  
x x f f f ★

`\xintRationalSeriesX{A}{B}{\first}{\ratio}{\g}` is a parametrized version of `\xintRationalSeries` where `\first` is now a one-parameter macro such that `\first{\g}` gives the initial term and `\ratio` is a two-parameter macro such that `\ratio{n}{\g}` represents the ratio of one term to the previous one. The parameter `\g` is evaluated only once at the beginning of the computation, and can thus itself be the yet unevaluated result of a previous computation.

Let `\ratio` be such a two-parameter macro; note the subtle differences between

`\xintRationalSeries {A}{B}{\first}{\ratio{\g}}`

and `\xintRationalSeriesX {A}{B}{\first}{\ratio}{\g}`.

First the location of braces differ... then, in the former case `\first` is a *no-parameter* macro expanding to a fractional number, and in the latter, it is a *one-parameter* macro which will use `\g`. Furthermore the X variant will expand `\g` at the very beginning whereas the former non-X former variant will evaluate it each time it needs it (which is bad if this evaluation is time-costly, but good if `\g` is a big explicit fraction encapsulated in a macro).

The example will use the macro `\xintPowerSeries` which computes efficiently exact partial sums of power series, and is discussed in the next section.

```

\def\firstterm #1{1[0]}% first term of the exponential series
% although it is the constant 1, here it must be defined as a
% one-parameter macro. Next comes the ratio function for exp:
\def\ratioexp #1#2{\xintDiv {#1}{#2}}% x/n
% These are the (-1)^{n-1}/n of the log(1+h) series:
\def\coefflog #1{\the\numexpr\ifodd #1 1\else-1\fi\relax/#1[0]}%
% Let L(h) be the first 10 terms of the log(1+h) series and
% let E(t) be the first 10 terms of the exp(t) series.
% The following computes E(L(a/10)) for a=1,...,12.
\cnta 0
\loop
\noindent\xintTrunc {18}{%
  \xintRationalSeriesX {0}{9}{\firstterm}{\ratioexp}
  {\xintPowerSeries{1}{10}{\coefflog}{\the\cnta[-1]}}}\dots
\endgraf
\ifnum\cnta < 12 \advance \cnta 1 \repeat

```

```
1.099999999999083906... 1.499954310225476533... 1.870485649686617459...
1.199999998111624029... 1.599659266069210466... 1.907197560339468199...
1.299999835744121464... 1.698137473697423757... 1.845117565491393752...
1.399996091955359088... 1.791898112718884531... 1.593831932293536053...
```

These completely exact operations rapidly create numbers with many digits. Let us print in full the raw fractions created by the operation illustrated above:

```
E(L(1[-1]))=4355349527343049937531284783056957554465259984189164206
56308534427154141471013807206588202981046013155342233701289165089056
83005693656447898877952000000000/39594086612242519324387557078266845
77630388224000000000000000000000[-90] (length of numerator: 155)
```

```
E(L(12[-2]))=443453770054417465442109252347264824711893599160411729
60388258419808415322610807070750589009628030597103713328020346412371
55887714188380658982959014134632946402759999397422009303463626532643
5417048639843167445553122713679545984140443648000000000/395940866122
4251932438755707826684577630388224000000000000000000000000[-180] (length of
numerator: 245)
```

```
E(L(123[-3]))=44464159265194177715425414884885486619895497155261639
00742959135317921138508647797623508008144169817627741486630524932175
66759754097977420731516373336789722730765496139079185229545102248282
39119962102923779381174012211091973543316113275716895586401771088185
05853950798598438316179662071953915678034718321474363029365556301004
8000000000/395940866122425193243875570782668457763038822400000000000
0000000000[-270] (length of numerator: 335)
```

We see that the denominators here remain the same, as our input only had various powers of ten as denominators, and *xintfrac* efficiently assemble (some only, as we can see) powers of ten. Notice that 1 more digit in an input denominator seems to mean 90 more in the raw output. We can check that with some other test cases:

```
E(L(1/7))=518138516117322604916074833164833344883840590133006168125
12534667430913353255394804713669158571590044976892591448945234186435
1924224000000000/453371201621089791788096627821377652892232653817581
52546654836095087089601022689942796465342115407786358809263904208715
776000000000000000000000[0] (length of numerator: 141; length of denominator: 141)
```

```
E(L(1/71))=16479948917721955649802595580610709825615810175620936986
46571522821497800830677980391753251868507166092934678546038421637547
16919123274624394132188208895310089982001627351524910000588238596565
3808879162861533474038814343168000000000/162510607383091507102283159
26583043448560635097998286551792304600401711584442548604911127392639
47128502616674265101594835449174751466360330459637981998261154868149
55381536472641379276308916890414267771321449447424000000000000000000
0[0] (length of numerator: 232; length of denominator: 232)
```

```
E(L(1/712))=2096231738801631206754816378972162002839689022482032389
43136902264182865559717266406341976325767001357109452980607391271438
07919507395930152825400608790815688812956752026901171545996915468879
90896257382714338565353779187008849807986411970218551170786297803168
353530430674157534972120128999850190174947982205517824000000000/2093
29172233767379973271986231161997566292788454774484652603429574146596
```

81775830937864120504809583013570752212138965469030119839610806057249  
 0342602456343055829220334691330984419090140201839416227006587667057  
 5550330002721292096217682473000829618103432600036119035084894266166  
 64834303221920647163859173376000000000000000000 [0] (length of numerator:  
 322; length of denominator: 322)

For info the last fraction put into irreducible form still has 288 digits in its denominator.<sup>67</sup> Thus decimal numbers such as 0.123 (equivalently  $123[-3]$ ) give less computing intensive tasks than fractions such as  $1/712$ : in the case of decimal numbers the (raw) denominators originate in the coefficients of the series themselves, powers of ten of the input within brackets being treated separately. And even then the numerators will grow with the size of the input in a sort of linear way, the coefficient being given by the order of series: here 10 from the log and 9 from the exp, so 90. One more digit in the input means 90 more digits in the numerator of the output: obviously we can not go on composing such partial sums of series and hope that **xint** will joyfully do all at the speed of light! Briefly said, imagine that the rules of the game make the programmer like a security guard at an airport scanning machine: a never-ending flux of passengers keep on arriving and all you can do is re-shuffle the first nine of them, organize marriages among some, execute some, move children farther back among the first nine only. If a passenger comes along with many hand luggages, this will slow down the process even if you move him to ninth position, because sooner or later you will have to digest him, and the children will be big too. There is no way to move some guy out of the file and to a discrete interrogatory room for separate treatment or to give him/her some badge saying “I left my stuff in storage box 357”.

Hence, truncating the output (or better, rounding) is the only way to go if one needs a general calculus of special functions. This is why the package **xintseries** provides, besides `\xintSeries`, `\xintRationalSeries`, or `\xintPowerSeries` which compute *exact* sums, also has `\xintFxFtPowerSeries` for fixed-point computations.

Update: release 1.08a of **xintseries** now includes a tentative naive `\xintFloatPowerSeries`.

### 33.5 `\xintPowerSeries`

`\xintPowerSeries{A}{B}{\coeff}{f}` evaluates the sum  $\sum_{n=A}^{n=B} \text{\coeff}\{n\} \cdot f^n$ . The initial and final indices are given to a `\numexpr` expression. The `\coeff` macro (which, as argument to `\xintPowerSeries` is expanded only at the time `\coeff{n}` is needed) should be defined as a one-parameter expandable command, its input will be an explicit number.

The `f` can be either a fraction directly input or a macro `\f` expanding to such a fraction. It is actually more efficient to encapsulate an explicit fraction `f` in such a macro, if it has big numerators and denominators (‘big’ means hundreds of digits) as it will then take less space in the processing until being (repeatedly) used.

This macro computes the *exact* result (one can use it also for polynomial evaluation). Starting with release 1.04 a Horner scheme for polynomial evaluation is used, which has the advantage to avoid a denominator build-up which was plaguing the 1.03 version.<sup>68</sup>

<sup>67</sup> putting this fraction in irreducible form takes more time than is typical of the other computations in this document; so exceptionally I have hard-coded the 288 in the document source. <sup>68</sup> with powers  $f^k$ , from  $k=0$  to  $N$ , a denominator  $d$  of  $f$  became  $d^{1+2+\dots+N}$ , which is bad. With the 1.04 method, the part of the denominator originating from  $f$  does not accumulate to more than  $d^N$ .

Note: as soon as the coefficients look like factorials, it is more efficient to use the `\xintRationalSeries` macro whose evaluation, also based on a similar Horner scheme, will avoid a denominator build-up originating in the coefficients themselves.

```

\def\geom #1{1[0]} % the geometric series
\def\fr {5/17[0]}
\[ \sum_{n=0}^{\infty} \Bigl(\frac{5}{17}\Bigr)^n
= \xintFrac{\xintIrr{\xintPowerSeries {0}{20}{\geom}{\fr}}}
= \xintFrac{\xinttheexpr (17^21-5^21)/12/17^20\relax}\]


$$\sum_{n=0}^{20} \left(\frac{5}{17}\right)^n = \frac{5757661159377657976885341}{4064231406647572522401601} = \frac{69091933912531895722624092}{48770776879770870268819212}$$


\def\coefflog #1{1/#1[0]}% 1/n
\def\fr {1/2[0]}%
\[ \log 2 \approx \sum_{n=1}^{\infty} \frac{1}{n \cdot 2^n}
= \xintFrac {\xintIrr {\xintPowerSeries {1}{20}{\coefflog}{\fr}}}
\[ \log 2 \approx \sum_{n=1}^{\infty} \frac{1}{n \cdot 2^n}
= \xintFrac {\xintIrr {\xintPowerSeries {1}{50}{\coefflog}{\fr}}}


$$\log 2 \approx \sum_{n=1}^{20} \frac{1}{n \cdot 2^n} = \frac{42299423848079}{61025172848640}$$



$$\log 2 \approx \sum_{n=1}^{50} \frac{1}{n \cdot 2^n} = \frac{60463469751752265663579884559739219}{87230347965792839223946208178339840}$$


\cnta 1 % previously declared count
\loop % in this loop we recompute from scratch each partial sum!
% we can afford that, as \xintPowerSeries is fast enough.
\noindent\hbox to 2em{\hfil\texttt{\the\cnta.} }%
\xintTrunc {12}
{\xintPowerSeries {1}{\cnta}{\coefflog}{\fr}}\dots
\endgraf
\ifnum \cnta < 30 \advance\cnta 1 \repeat

1. 0.500000000000...    11. 0.693109245355...    21. 0.693147159757...
2. 0.625000000000...    12. 0.693129590407...    22. 0.693147170594...
3. 0.666666666666...    13. 0.693138980431...    23. 0.693147175777...
4. 0.682291666666...    14. 0.693143340085...    24. 0.693147178261...
5. 0.688541666666...    15. 0.693145374590...    25. 0.693147179453...
6. 0.691145833333...    16. 0.693146328265...    26. 0.693147180026...
7. 0.692261904761...    17. 0.693146777052...    27. 0.693147180302...
8. 0.692750186011...    18. 0.693146988980...    28. 0.693147180435...
9. 0.692967199900...    19. 0.693147089367...    29. 0.693147180499...
10. 0.693064856150...    20. 0.693147137051...    30. 0.693147180530...

%\def\coeffarctg #1{1/\the\numexpr\xintMON{#1}*(2*#1+1)\relax }%
```

```

\def\coeffarctg #1{1/\the\numexpr\ifodd #1 -2*#1-1\else2*#1+1\fi\relax }%
% the above gives (-1)^n/(2n+1). The sign being in the denominator,
%      **** no [0] should be added ****,
% else nothing is guaranteed to work (even if it could by sheer luck)
% NOTE in passing this aspect of \numexpr:
%      **** \numexpr -(1)\relax does not work!!! ****
\def\fractg {1/25[0]}% 1/5^2
\[\mathrm{Arctg}(\frac{1}{5})\approx
\frac{1}{5}\sum_{n=0}^{15} \frac{(-1)^n}{(2n+1)25^n} = \frac{165918726519122955895391793269168}{840539304153062403202056884765625}
= \xintFrac{\xintIrr {\xintDiv
{\xintPowerSeries {0}{15}{\coeffarctg}{f}}{5}}}{\xintDiv
{\xintPowerSeries {0}{15}{\coeffarctg}{f}}{5}}}\]

```

$$\operatorname{Arctg}\left(\frac{1}{5}\right) \approx \frac{1}{5} \sum_{n=0}^{15} \frac{(-1)^n}{(2n+1)25^n} = \frac{165918726519122955895391793269168}{840539304153062403202056884765625}$$

### 33.6 \xintPowerSeriesX

$\frac{\frac{\text{num}}{x} \frac{\text{num}}{x}}{\frac{\text{Frac}}{f} \frac{\text{Frac}}{f}}$

This is the same as `\xintPowerSeries` apart from the fact that the last parameter `f` is expanded once and for all before being then used repeatedly. If the `f` parameter is to be an explicit big fraction with many (dozens) digits, rather than using it directly it is slightly better to have some macro `\g` defined to expand to the explicit fraction and then use `\xintPowerSeries` with `\g`; but if `f` has not yet been evaluated and will be the output of a complicated expansion of some `\f`, and if, due to an expanding only context, doing `\edef \g{\f}` is no option, then `\xintPowerSeriesX` should be used with `\f` as last parameter.

```

\def\ratioexp #1#2{\xintDiv {#1}{#2}}% x/n
% These are the (-1)^{n-1}/n of the log(1+h) series:
\def\coefflog #1{\the\numexpr\ifodd #1 1\else-1\fi\relax/#1[0]}%
% Let L(h) be the first 10 terms of the log(1+h) series and
% let E(t) be the first 10 terms of the exp(t) series.
% The following computes L(E(a/10)-1) for a=1,..., 12.
\cnta 1
\loop
\noindent\xintTrunc {18}{%
\xintPowerSeriesX {1}{10}{\coefflog}
{\xintSub
{\xintRationalSeries {0}{9}{1[0]}{\ratioexp{\the\cnta[-1]}}
{1}}}\dots
}\endgraf
\ifnum\cnta < 12 \advance\cnta 1 \repeat

0.099999999998556159... 0.499511320760604148... -1.597091692317639401...
0.1999999995263443554... 0.593980619762352217... -12.648937932093322763...
0.299999338075041781... 0.645144282733914916... -66.259639046914679687...
0.399974460740121112... 0.398118280111436442... -304.768437445462801227...

```

### 33.7 \xintFxFtPowerSeries

$\frac{\frac{\frac{\text{num}}{x} \frac{\text{num}}{x}}{\frac{\text{Frac}}{f} \frac{\text{Frac}}{f}} \frac{\text{num}}{x}}{\frac{\text{Frac}}{f} \frac{\text{Frac}}{f}}$

`\xintFxFtPowerSeries{A}{B}{\coeff}{f}{D}` computes  $\sum_{n=A}^{n=B} \text{coeff}\{n\} \cdot f^n$  with each term of the series truncated to `D` digits after the decimal point. As usual, `A` and `B` are

completely expanded through their inclusion in a `\numexpr` expression. Regarding `D` it will be similarly be expanded each time it is used inside an `\xintTrunc`. The one-parameter macro `\coeff` is similarly expanded at the time it is used inside the computations. Idem for `f`. If `f` itself is some complicated macro it is thus better to use the variant `\xint-FxPtPowerSeriesX` which expands it first and then uses the result of that expansion.

The current (1.04) implementation is: the first power  $f^A$  is computed exactly, then *truncated*. Then each successive power is obtained from the previous one by multiplication by the exact value of `f`, and truncated. And  $\text{coeff}\{n\} \cdot f^n$  is obtained from that by multiplying by `\coeff{n}` (untruncated) and then truncating. Finally the sum is computed exactly. Apart from that `\xintFxPtPowerSeries` (where `FxPt` means ‘fixed-point’) is like `\xintPowerSeries`.

There should be a variant for things of the type  $\sum c_n \frac{f^n}{n!}$  to avoid having to compute the factorial from scratch at each coefficient, the same way `\xintFxPtPowerSeries` does not compute  $f^n$  from scratch at each `n`. Perhaps in the next package release.

$$e^{-\frac{1}{2}} \approx$$

1.00000000000000000000	0.60653056795634920635	0.60653065971263344622
0.50000000000000000000	0.60653066483754960317	0.60653065971263342289
0.62500000000000000000	0.60653065945526069224	0.60653065971263342361
0.60416666666666666667	0.60653065972437513778	0.60653065971263342359
0.60677083333333333333	0.60653065971214266299	0.60653065971263342359
0.60651041666666666667	0.60653065971265234943	0.60653065971263342359
0.60653211805555555555	0.60653065971263274611	

```
\def\coeffexp #1{1/\xintFac {#1}[0]}% 1/n!
```

```
\def\ f {-1/2[0]}% [0] for faster input parsing
```

```
\cnta 0 % previously declared \count register
```

```
\noindent\loop
```

```
 $\xintFxPtPowerSeries {0}{\cnta}{\coeffexp}{\ f}{20}$\
```

```
\ifnum\cnta<19 \advance\cnta 1 \repeat\par
```

```
% One should not trust the final digits, as the potential truncation
% errors of up to  $10^{-20}$  per term accumulate and never disappear! (the
% effect is attenuated by the alternating signs in the series). We can
% confirm that the last two digits (of our evaluation of the nineteenth
% partial sum) are wrong via the evaluation with more digits:
```

```
\xintFxPtPowerSeries {0}{19}{\coeffexp}{\ f}{25}= 0.6065306597126334236037992
```

It is no difficulty for **xintfrac** to compute exactly, with the help of `\xintPowerSeries`, the nineteenth partial sum, and to then give (the start of) its exact decimal expansion:

$$\begin{aligned} \text{\xintPowerSeries {0}{19}{\coeffexp}{\ f}} &= \frac{38682746160036397317757}{63777066403145711616000} \\ &= 0.606530659712633423603799152126 \dots \end{aligned}$$

Thus, one should always estimate a priori how many ending digits are not reliable: if there are `N` terms and `N` has `k` digits, then digits up to but excluding the last `k` may usually be trusted. If we are optimistic and the series is alternating we may even replace `N` with  $\sqrt{N}$  to get the number `k` of digits possibly of dubious significance.

### 33.8 `\xintFxPtPowerSeriesX`

num num  
x x

`\xintFxPtPowerSeriesX{A}{B}{\coeff}{\ f}{D}` computes, exactly as `\xintFxPt-`

$$\frac{f}{f} \frac{f}{f} \frac{\text{num}}{x} \star$$

**PowerSeries**, the sum of  $\text{\coeff{n}} \cdot f^n$  from  $n=A$  to  $n=B$  with each term of the series being *truncated* to  $D$  digits after the decimal point. The sole difference is that  $f$  is first expanded and it is the result of this which is used in the computations.

Let us illustrate this on the numerical exploration of the identity

$$\log(1+x) = -\log(1/(1+x))$$

Let  $L(h)=\log(1+h)$ , and  $D(h)=L(h)+L(-h/(1+h))$ . Theoretically thus,  $D(h)=0$  but we shall evaluate  $L(h)$  and  $-h/(1+h)$  keeping only 10 terms of their respective series. We will assume  $|h| < 0.5$ . With only ten terms kept in the power series we do not have quite 3 digits precision as  $2^{10}=1024$ . So it wouldn't make sense to evaluate things more precisely than, say circa 5 digits after the decimal points.

```
\cnta 0
\def\coefflog #1{\the\numexpr\ifodd#1 1\else-1\fi\relax/#1[0]}% (-1)^(n-1)/n
\def\coeffalt #1{\the\numexpr\ifodd#1 -1\else1\fi\relax [0]}% (-1)^n
\loop
\noindent \hbox to 2.5cm {\hss\texttt{D(\the\cnta/100): }}%
\xintAdd {\xintFxFtPowerSeriesX {1}{10}{\coefflog}{\the\cnta [-2]}\{5}}
{\xintFxFtPowerSeriesX {1}{10}{\coefflog}
{\xintFxFtPowerSeriesX {1}{10}{\coeffalt}{\the\cnta [-2]}\{5}}
{5}}\endgraf
\ifnum\cnta < 49 \advance\cnta 7 \repeat
D(0/100): 0/1[0] D(28/100): 4/1[-5]
D(7/100): 2/1[-5] D(35/100): 4/1[-5]
D(14/100): 2/1[-5] D(42/100): 9/1[-5]
D(21/100): 3/1[-5] D(49/100): 42/1[-5]
```

Let's say we evaluate functions on  $[-1/2, +1/2]$  with values more or less also in  $[-1/2, +1/2]$  and we want to keep 4 digits of precision. So, roughly we need at least 14 terms in series like the geometric or log series. Let's make this 15. Then it doesn't make sense to compute intermediate summands with more than 6 digits precision. So we compute with 6 digits precision but return only 4 digits (rounded) after the decimal point. This result with 4 post-decimal points precision is then used as input to the next evaluation.

```
\loop
\noindent \hbox to 2.5cm {\hss\texttt{D(\the\cnta/100): }}%
\xintRound{4}
{\xintAdd {\xintFxFtPowerSeriesX {1}{15}{\coefflog}{\the\cnta [-2]}\{6}}
{\xintFxFtPowerSeriesX {1}{15}{\coefflog}
{\xintRound {4}{\xintFxFtPowerSeriesX {1}{15}{\coeffalt}
{\the\cnta [-2]}\{6}}
{6}}}%
}\endgraf
\ifnum\cnta < 49 \advance\cnta 7 \repeat
D(0/100): 0 D(28/100): -0.0001
D(7/100): 0.0000 D(35/100): -0.0001
D(14/100): 0.0000 D(42/100): -0.0000
D(21/100): -0.0001 D(49/100): -0.0001
```

Not bad... I have cheated a bit: the 'four-digits precise' numeric evaluations were left unrounded in the final addition. However the inner rounding to four digits worked fine and made the next step faster than it would have been with longer inputs. The morale is that one

should not use the raw results of `\xintFxFtPowerSeriesX` with the  $D$  digits with which it was computed, as the last are to be considered garbage. Rather, one should keep from the output only some smaller number of digits. This will make further computations faster and not less precise. I guess there should be some command to do this final truncating, or better, rounding, at a given number  $D' < D$  of digits. Maybe for the next release.

### 33.9 `\xintFloatPowerSeries`

$\left[ \begin{smallmatrix} \text{num} & \text{num} & \text{num} \\ \text{X} & \text{X} & \text{X} \\ \text{Frac} & \text{Frac} & \text{Frac} \\ f & f & f \end{smallmatrix} \right] \star$

`\xintFloatPowerSeries[P]{A}{B}{\coeff}{f}` computes  $\sum_{n=A}^{n=B} \text{coeff}\{n\} \cdot f^n$  with a floating point precision given by the optional parameter  $P$  or by the current setting of `\xintDigits`.

In the current, preliminary, version, no attempt has been made to try to guarantee to the final result the precision  $P$ . Rather,  $P$  is used for all intermediate floating point evaluations. So rounding errors will make some of the last printed digits invalid. The operations done are first the evaluation of  $f^A$  using `\xintFloatPow`, then each successive power is obtained from this first one by multiplication by  $f$  using `\xintFloatMul`, then again with `\xintFloatMul` this is multiplied with `\coeff{n}`, and the sum is done adding one term at a time with `\xintFloatAdd`. To sum up, this is just the naive transformation of `\xintFxFtPowerSeries` from fixed point to floating point.

```
\def\coefflog #1{\the\numexpr\ifodd#1 1\else-1\fi\relax/#1[0]}%
\xintFloatPowerSeries [8]{1}{30}{\coefflog}{-1/2[0]}
-6.9314718e-1
```

### 33.10 `\xintFloatPowerSeriesX`

$\left[ \begin{smallmatrix} \text{num} & \text{num} & \text{num} \\ \text{X} & \text{X} & \text{X} \\ \text{Frac} & \text{Frac} & \text{Frac} \\ f & f & f \end{smallmatrix} \right] \star$

`\xintFloatPowerSeriesX[P]{A}{B}{\coeff}{f}` is like `\xintFloatPowerSeries` with the difference that  $f$  is expanded once and for all at the start of the computation, thus allowing efficient chaining of such series evaluations.

```
\def\coeffexp #1{1/\xintFac {#1}[0]}% 1/n! (exact, not float)
\def\coefflog #1{\the\numexpr\ifodd#1 1\else-1\fi\relax/#1[0]}%
\xintFloatPowerSeriesX [8]{0}{30}{\coeffexp}
{\xintFloatPowerSeries [8]{1}{30}{\coefflog}{-1/2[0]}}
5.0000001e-1
```

### 33.11 Computing $\log 2$ and $\pi$

In this final section, the use of `\xintFxFtPowerSeries` (and `\xintPowerSeries`) will be illustrated on the (expandable... why make things simple when it is so easy to make them difficult!) computations of the first digits of the decimal expansion of the familiar constants  $\log 2$  and  $\pi$ .

Let us start with  $\log 2$ . We will get it from this formula (which is left as an exercise):

$$\log(2) = -2 \log(1 - 13/256) - 5 \log(1 - 1/9)$$

The number of terms to be kept in the log series, for a desired precision of  $10^{-D}$  was roughly estimated without much theoretical analysis. Computing exactly the partial sums with `\xintPowerSeries` and then printing the truncated values, from  $D=0$  up to  $D=100$  showed that it worked in terms of quality of the approximation. Because of possible strings of zeros or nines in the exact decimal expansion (in the present case of  $\log 2$ , strings of

zeros around the fortieth and the sixtieth decimals), this does not mean though that all digits printed were always exact. In the end one always end up having to compute at some higher level of desired precision to validate the earlier result.

Then we tried with `\xintFxFtPowerSeries`: this is worthwhile only for  $D$ 's at least 50, as the exact evaluations are faster (with these short-length  $f$ 's) for a lower number of digits. And as expected the degradation in the quality of approximation was in this range of the order of two or three digits. This meant roughly that the  $3+1=4$  ending digits were wrong. Again, we ended up having to compute with five more digits and compare with the earlier value to validate it. We use truncation rather than rounding because our goal is not to obtain the correct rounded decimal expansion but the correct exact truncated one.

```
\def\coefflog #1{1/#1[0]}% 1/n
\def\xa {13/256[0]}% we will compute log(1-13/256)
\def\xb {1/9[0]}% we will compute log(1-1/9)
\def\LogTwo #1%
% get log(2)=-2log(1-13/256)- 5log(1-1/9)
{% we want to use \printnumber, hence need something expanding in two steps
% only, so we use here the \romannumeral0 method
\romannumeral0\expandafter\LogTwoDoIt \expandafter
% Nb Terms for 1/9:
{\the\numexpr #1*150/143\expandafter}\expandafter
% Nb Terms for 13/256:
{\the\numexpr #1*100/129\expandafter}\expandafter
% We print #1 digits, but we know the ending ones are garbage
{\the\numexpr #1\relax}% allows #1 to be a count register
}%
\def\LogTwoDoIt #1#2#3%
% #1=nb of terms for 1/9, #2=nb of terms for 13/256,
{% #3=nb of digits for computations, also used for printing
\xinttrunc {#3}% lowercase form to stop the \romannumeral0 expansion!
{\xintAdd
{\xintMul {2}{\xintFxFtPowerSeries {1}{#2}{\coefflog}{\xa}{#3}}}
{\xintMul {5}{\xintFxFtPowerSeries {1}{#1}{\coefflog}{\xb}{#3}}}%
}%
}%
\noindent $\log 2 \approx \LogTwo {60}\dots$\endgraf
\noindent\phantom{$\log 2$}\approx{}\printnumber{\LogTwo {65}}\dots\endgraf
\noindent\phantom{$\log 2$}\approx{}\printnumber{\LogTwo {70}}\dots\endgraf
log 2  $\approx$  0.693147180559945309417232121458176568075500134360255254120484...
 $\approx$  0.693147180559945309417232121458176568075500134360255254120680
00711...
 $\approx$  0.693147180559945309417232121458176568075500134360255254120680
0094933723...
```

Here is the code doing an exact evaluation of the partial sums. We have added a  $+1$  to the number of digits for estimating the number of terms to keep from the log series: we experimented that this gets exactly the first  $D$  digits, for all values from  $D=0$  to  $D=100$ , except in one case ( $D=40$ ) where the last digit is wrong. For values of  $D$  higher than 100 it is more efficient to use the code using `\xintFxFtPowerSeries`.

```
\def\LogTwo #1% get log(2)=-2log(1-13/256)- 5log(1-1/9)
{%
```

```

\romannumeral0\expandafter\LogTwoDoIt \expandafter
{\the\numexpr (#1+1)*150/143\expandafter}\expandafter
{\the\numexpr (#1+1)*100/129\expandafter}\expandafter
{\the\numexpr #1\relax}%
}%
\def\LogTwoDoIt #1#2#3%
{% #3=nb of digits for truncating an EXACT partial sum
\ointttrunc {#3}
{\ointAdd
{\ointMul {2}{\ointPowerSeries {1}{#2}{\coefflog}{\xa}}}}
{\ointMul {5}{\ointPowerSeries {1}{#1}{\coefflog}{\xb}}}%
}%
}%

Let us turn now to Pi, computed with the Machin formula. Again the numbers of terms to
keep in the two arctg series were roughly estimated, and some experimentations showed
that removing the last three digits was enough (at least for D=0-100 range). And the al-
gorithm does print the correct digits when used with D=1000 (to be convinced of that one
needs to run it for D=1000 and again, say for D=1010.) A theoretical analysis could help
confirm that this algorithm always gets better than  $10^{-D}$  precision, but again, strings of
zeros or nines encountered in the decimal expansion may falsify the ending digits, nines
may be zeros (and the last non-nine one should be increased) and zeros may be nine (and
the last non-zero one should be decreased).

% pi = 16 Arctg(1/5) - 4 Arctg(1/239) (John Machin's formula)
\def\coeffarctg #1{\the\numexpr ifodd#1 -1\else1\fi\relax/%
\the\numexpr 2*#1+1\relax [0]}%

% the above computes  $(-1)^n/(2n+1)$ .
\def\xa {1/25[0]}% 1/5^2, the [0] for (infinitesimally) faster pars-
ing
\def\xb {1/57121[0]}% 1/239^2, the [0] for faster parsing
\def\Machin #1{% \Machin {\mycount} is allowed
\romannumeral0\expandafter\MachinA \expandafter
% number of terms for arctg(1/5):
{\the\numexpr (#1+3)*5/7\expandafter}\expandafter
% number of terms for arctg(1/239):
{\the\numexpr (#1+3)*10/45\expandafter}\expandafter
% do the computations with 3 additional digits:
{\the\numexpr #1+3\expandafter}\expandafter
% allow #1 to be a count register:
{\the\numexpr #1\relax }}%
\def\MachinA #1#2#3#4%
% #4: digits to keep after decimal point for final printing
% #3=#4+3: digits for evaluation of the necessary number of terms
% to be kept in the arctangent series, also used to truncate each
% individual summand.
{\ointttrunc {#4} % lowercase macro to match the initial \romannumeral0.
{\ointSub
{\ointMul {16/5}{\ointFxPtPowerSeries {0}{#1}{\coeffarctg}{\xa}{#3}}}}
{\ointMul {4/239}{\ointFxPtPowerSeries {0}{#2}{\coeffarctg}{\xb}{#3}}}%
}}%
\[\pi = \Machin {60}\dots \]

```

$$\pi = 3.141592653589793238462643383279502884197169399375105820974944 \dots$$

Here is a variant `\MachinBis`, which evaluates the partial sums *exactly* using `\xintPowerSeries`, before their final truncation. No need for a “+3” then.

```
\def\MachinBis #1{% #1 may be a count register,
% the final result will be truncated to #1 digits post decimal point
  \romannumeral0\expandafter\MachinBisA \expandafter
    % number of terms for arctg(1/5):
    {\the\numexpr #1*5/7\expandafter}\expandafter
    % number of terms for arctg(1/239):
    {\the\numexpr #1*10/45\expandafter}\expandafter
    % allow #1 to be a count register:
    {\the\numexpr #1\relax }}%
\def\MachinBisA #1#2#3%
{\xinttrunc {#3} %
  {\xintSub
    {\xintMul {16/5}{\xintPowerSeries {0}{#1}{\coeffarctg}{\xa}}}%
    {\xintMul {4/239}{\xintPowerSeries {0}{#2}{\coeffarctg}{\xb}}}%
  }}%
```

Let us use this variant for a loop showing the build-up of digits:

```
\cnta 0 % previously declared \count register
\loop
\MachinBis{\cnta} \endgraf % Plain's \loop does not accept \par
\ifnum\cnta < 30 \advance\cnta 1 \repeat
```

	3.141592653589793
3.	3.1415926535897932
3.1	3.14159265358979323
3.14	3.141592653589793238
3.141	3.1415926535897932384
3.1415	3.14159265358979323846
3.14159	3.141592653589793238462
3.141592	3.1415926535897932384626
3.1415926	3.14159265358979323846264
3.14159265	3.141592653589793238462643
3.141592653	3.1415926535897932384626433
3.1415926535	3.14159265358979323846264338
3.14159265358	3.141592653589793238462643383
3.141592653589	3.1415926535897932384626433832
3.1415926535897	3.14159265358979323846264338327
3.14159265358979	3.141592653589793238462643383279

You want more digits and have some time? Copy the `\Machin` code to a T<sub>E</sub>X file, and compile it with `etex` (or `pdftex`):

```
% Compile with e-TeX extensions enabled (etex, pdftex, ...)
\input xintfrac.sty
\input xintseries.sty
```

```

% pi = 16 Arctg(1/5) - 4 Arctg(1/239) (John Machin's formula)
\def\coeffarctg #1{\the\numexpr\ifodd#1 -1\else1\fi\relax/%
                    \the\numexpr 2*#1+1\relax [0]}%
\def\xa {1/25[0]}%
\def\xb {1/57121[0]}%
\def\Machin #1{%
  \romannumeral0\expandafter\MachinA \expandafter
  {\the\numexpr (#1+3)*5/7\expandafter}\expandafter
  {\the\numexpr (#1+3)*10/45\expandafter}\expandafter
  {\the\numexpr #1+3\expandafter}\expandafter
  {\the\numexpr #1\relax }}%
\def\MachinA #1#2#3#4%
{\xinttrunc {#4}
 {\xintSub
  {\xintMul {16/5}{\xintFxFtPowerSeries {0}{#1}{\coeffarctg}{\xa}{#3}}}
  {\xintMul {4/239}{\xintFxFtPowerSeries {0}{#2}{\coeffarctg}{\xb}{#3}}}%
 }}%
\pdfresettimer
\oodef\Z {\Machin {1000}}
\odef\W {\the\pdfelapsedtime}
\message{\Z}
\message{computed in \xintRound {2}{\W/65536} seconds.}
\bye

```

This will log the first 1000 digits of  $\pi$  after the decimal point. On my laptop (a 2012 model) this took about 16 seconds last time I tried.<sup>69</sup> As mentioned in the introduction, the file [pi.tex](#) by D. ROEGEL shows that orders of magnitude faster computations are possible within T<sub>E</sub>X, but recall our constraints of complete expandability and be merciful, please.

**Why truncating rather than rounding?** One of our main competitors on the market of scientific computing, a canadian product (not encumbered with expandability constraints, and having barely ever heard of T<sub>E</sub>X ;-), prints numbers rounded in the last digit. Why didn't we follow suit in the macros `\xintFxFtPowerSeries` and `\xintFxFtPowerSeriesX`? To round at D digits, and excluding a rewrite or cloning of the division algorithm which anyhow would add to it some overhead in its final steps, *xintfrac* needs to truncate at D+1, then round. And rounding loses information! So, with more time spent, we obtain a worst result than the one truncated at D+1 (one could imagine that additions and so on, done with only D digits, cost less; true, but this is a negligible effect per summand compared to the additional cost for this term of having been truncated at D+1 then rounded). Rounding is the way to go when setting up algorithms to evaluate functions destined to be composed one after the other: exact algebraic operations with many summands and an *f* variable which is a fraction are costly and create an even bigger fraction; replacing *f* with a reasonable rounding, and rounding the result, is necessary to allow arbitrary chaining.

But, for the computation of a single constant, we are really interested in the exact decimal expansion, so we truncate and compute more terms until the earlier result gets validated. Finally if we do want the rounding we can always do it on a value computed with D+1 truncation.

<sup>69</sup> With 1.09i and earlier *xint* releases, this used to be 42 seconds; the 1.09j division is much faster with small denominators as occurs here with `\xa=1/25`, and I believe this to be the main explanation for the speed gain.

## 34 Commands of the **xintcfrac** package

This package was first included in release 1.04 of the **xint** bundle.

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### 34.1 Package overview

A *simple* continued fraction has coefficients  $[c_0, c_1, \dots, c_N]$  (usually called partial quotients, but I really dislike this entrenched terminology), where  $c_0$  is a positive or negative integer and the others are positive integers. As we will see it is possible with **xintcfrac** to specify the coefficient function  $c:n \rightarrow c_n$ . Note that the index then starts at zero as indicated. With the `amsmath` macro `\cfrac` one can display such a continued fraction as

$$c_0 + \frac{1}{c_1 + \frac{1}{c_2 + \frac{1}{c_3 + \frac{1}{\ddots}}}}$$

Here is a concrete example:

$$\frac{208341}{66317} = 3 + \frac{1}{7 + \frac{1}{15 + \frac{1}{1 + \frac{1}{292 + \frac{1}{2}}}}}$$

But the difference with `amsmath`'s `\cfrac` is that this was input as

```
\[ \xintFrac {208341/66317}=\xintCFrac {208341/66317} \]
```

The command `\xintCFrac` produces in two expansion steps the whole thing with the many

chained `\cfrac`'s and all necessary braces, ready to be printed, in math mode. This is  $\text{\LaTeX}$  only and with the `amsmath` package (we shall mention another method for Plain  $\text{\TeX}$  users of `amstex`).

A *generalized* continued fraction has the same structure but the numerators are not restricted to be ones, and numbers used in the continued fraction may be arbitrary, also fractions, irrationals, indeterminates. The *centered* continued fraction associated to a rational number is an example:

$$\frac{915286}{188421} = 5 - \frac{1}{7 + \frac{1}{39 - \frac{1}{53 - \frac{1}{13}}}} = 4 + \frac{1}{1 + \frac{1}{6 + \frac{1}{38 + \frac{1}{1 + \frac{1}{51 + \frac{1}{1 + \frac{1}{12}}}}}}}$$

`\[ \xintFrac {915286/188421}=\xintGCfrac {\xintFtoCC {915286/188421}} \]`  
The command `\xintGCfrac`, contrarily to `\xintCfrac`, does not compute anything, it just typesets. Here, it is the command `\xintFtoCC` which did the computation of the centered continued fraction of  $f$ . Its output has the ‘inline format’ described in the next paragraph. In the display, we also used `\xintCfrac` (code not shown), for comparison of the two types of continued fractions.

A generalized continued fraction may be input ‘inline’ as:

$$a_0 + b_0/a_1 + b_1/a_2 + b_2/\dots/a_{n-1} + b_{n-1}/a_n$$

Fractions among the coefficients are allowed but they must be enclosed within braces. Signed integers may be left without braces (but the + signs are mandatory). Or, they may be macros expanding (in two steps) to some number or fractional number.

`\xintGCfrac {1+-1/57+\xintPow {-3}{7}/\xintQuo {132}{25}}`

$$\frac{1907}{1902} = 1 - \frac{1}{57 - \frac{2187}{5}}$$

The left hand side was obtained with the following code:

`\xintFrac{\xintGctoF {1+-1/57+\xintPow {-3}{7}/\xintQuo {132}{25}}}`

It uses the macro `\xintGctoF` to convert a generalized fraction from the ‘inline format’ to the fraction it evaluates to.

A simple continued fraction is a special case of a generalized continued fraction and may be input as such to macros expecting the ‘inline format’, for example  $-7+1/6+1/19+1/1+1/33$ . There is a simpler comma separated format:

`\xintFrac{\xintCstoF{-7,6,19,1,33}}=\xintCFrac{\xintCstoF{-7,6,19,1,33}}`

$$\frac{-28077}{4108} = -7 + \frac{1}{6 + \frac{1}{19 + \frac{1}{1 + \frac{1}{33}}}}$$

This comma separated format may also be used with fractions among the coefficients: in that case, computing with `\xintFtoCs` from the resulting `f` its real coefficients will give a new comma separated list with only integers. This list has no spaces: the spaces in the display below arise from the math mode processing.

`\xintFrac{1084483/398959}=[\xintFtoCs{1084483/398959}]`

$$\frac{1084483}{398959} = [2, 1, 2, 1, 1, 4, 1, 1, 6, 1, 1, 8, 1, 1, 10, 2]$$

If one prefers other separators, one can use `\xintFtoCx` whose first argument will be the separator to be used.

`\xintFrac{2721/1001}=\xintFtoCx {+1/(\{2721/1001\})\cdots}`

$$\frac{2721}{1001} = 2 + 1/(1 + 1/(2 + 1/(1 + 1/(1 + 1/(4 + 1/(1 + 1/(1 + 1/(6 + 1/(2) \cdots)))$$

People using Plain  $\text{\TeX}$  and `amstex` can achieve the same effect as `\xintCFrac` with: `$$\xintFwOver{2721/1001}=\xintFtoCx {+}\cfrac1{\{2721/1001\}}\endcfrac$$`

Using `\xintFtoCx` with first argument an empty pair of braces `{}` will return the list of the coefficients of the continued fraction of `f`, without separator, and each one enclosed in a pair of group braces. This can then be manipulated by the non-expandable macro `\xintAssignArray` or the expandable ones `\xintApply` and `\xintListWithSep`.

As a shortcut to using `\xintFtoCx` with separator `1+/,` there is `\xintFtoGC`:

`2721/1001=\xintFtoGC {2721/1001}`

$$2721/1001=2+1/1+1/2+1/1+1/1+1/4+1/1+1/1+1/6+1/2$$

Let us compare in that case with the output of `\xintFtoCC`:

`2721/1001=\xintFtoCC {2721/1001}`

$$2721/1001=3+-1/4+-1/2+1/5+-1/2+1/7+-1/2$$

The ‘`\printnumber`’ macro which we use to print long numbers can also be useful on long continued fractions.

`\printnumber{\xintFtoCC {35037018906350720204351049/%  
244241737886197404558180}}`

`143+1/2+1/5+-1/4+-1/4+-1/4+-1/3+1/2+1/2+1/6+-1/22+1/2+1/10+-1/5+-1/11+-1/3+1/4+-1/2+1/2+1/4+-1/2+1/23+1/3+1/8+-1/6+-1/9.` If we apply `\xintGctoF` to this generalized continued fraction, we discover that the original fraction was reducible:

`\xintGctoF {143+1/2+...+-1/9}=2897319801297630107/20197107104701740`

When a generalized continued fraction is built with integers, and numerators are only `1`’s or `-1`’s, the produced fraction is irreducible. And if we compute it again with the last sub-fraction omitted we get another irreducible fraction related to the bigger one by a Bezout identity. Doing this here we get:

`\xintGctoF {143+1/2+...+-1/6}=328124887710626729/2287346221788023`  
and indeed:

$$\begin{vmatrix} 2897319801297630107 & 328124887710626729 \\ 20197107104701740 & 2287346221788023 \end{vmatrix} = 1$$

More generally the various fractions obtained from the truncation of a continued fraction to its initial terms are called the convergents. The commands of **xintcf** such as `\xintFtoCv`, `\xintFtoCCv`, and others which compute such convergents, return them as a list of braced items, with no separator. This list can then be treated either with `\xintAssignArray`, or `\xintListWithSep`, or any other way (but then, some T<sub>E</sub>X programming knowledge will be necessary). Here is an example:

$$\begin{aligned} & \text{\$}\text{\xintFrac{915286/188421}}\text{\to} \text{\xintListWithSep {,}}\% \\ & \text{\{ \xintApply{\xintFrac}{\xintFtoCv{915286/188421}} \}}\text{\$}\$ \\ & \frac{915286}{188421} \rightarrow 4, 5, \frac{34}{7}, \frac{1297}{267}, \frac{1331}{274}, \frac{69178}{14241}, \frac{70509}{14515}, \frac{915286}{188421} \end{aligned}$$

$$\begin{aligned} & \text{\$}\text{\xintFrac{915286/188421}}\text{\to} \text{\xintListWithSep {,}}\% \\ & \text{\{ \xintApply{\xintFrac}{\xintFtoCCv{915286/188421}} \}}\text{\$}\$ \\ & \frac{915286}{188421} \rightarrow 5, \frac{34}{7}, \frac{1331}{274}, \frac{70509}{14515}, \frac{915286}{188421} \end{aligned}$$

We thus see that the ‘centered convergents’ obtained with `\xintFtoCCv` are among the fuller list of convergents as returned by `\xintFtoCv`.

Here is a more complicated use of `\xintApply` and `\xintListWithSep`. We first define a macro which will be applied to each convergent:

`\newcommand{\mymacro}[1]{\text{\xintFrac{#1}}=[\xintFtoCs{#1}]\text{\vtop to 6pt}}`  
Next, we use the following code:

`\text{\xintFrac{49171/18089}}\text{\to}\text{\$}`  
`\xintListWithSep {, }{\xintApply{\mymacro}{\xintFtoCv{49171/18089}}}`

It produces:

$$\begin{aligned} \frac{49171}{18089} \rightarrow 2 = [2], 3 = [3], \frac{8}{3} = [2, 1, 2], \frac{11}{4} = [2, 1, 3], \frac{19}{7} = [2, 1, 2, 2], \frac{87}{32} = [2, 1, 2, 1, 1, 4], \\ \frac{106}{39} = [2, 1, 2, 1, 1, 5], \frac{193}{71} = [2, 1, 2, 1, 1, 4, 2], \frac{1264}{465} = [2, 1, 2, 1, 1, 4, 1, 1, 6], \frac{1457}{536} = \\ [2, 1, 2, 1, 1, 4, 1, 1, 7], \frac{2721}{1001} = [2, 1, 2, 1, 1, 4, 1, 1, 6, 2], \frac{23225}{8544} = [2, 1, 2, 1, 1, 4, 1, 1, 6, 1, 1, 8], \\ \frac{49171}{18089} = [2, 1, 2, 1, 1, 4, 1, 1, 6, 1, 1, 8, 2]. \end{aligned}$$

The macro `\xintCntoF` allows to specify the coefficients as functions of the index. The values to which expand the coefficient function do not have to be integers.

`\def\cn #1{\xintiPow {2}{#1}}\%`  
`\[\xintFrac{\xintCntoF {6}}{\cn}=\xintCFrac [1]{\xintCntoF {6}}{\cn}\]`

$$\frac{3541373}{2449193} = 1 + \frac{1}{2 + \frac{1}{4 + \frac{1}{8 + \frac{1}{16 + \frac{1}{32 + \frac{1}{64}}}}}}$$

Notice the use of the optional argument [1] to `\xintCFrac`. Other possibilities are [r] and (default) [c].

```
\def\cn #1{\xintPow {2}{-#1}}% 1/2^n
\[\xintFrac{\xintCntoF {6}{\cn}} = \xintGCFrac [r]{\xintCntoGC {6}{\cn}}
= [\xintFtoCs {\xintCntoF {6}{\cn}}]\]
```

$$\frac{3159019}{2465449} = 1 + \frac{1}{\frac{1}{2} + \frac{1}{\frac{1}{4} + \frac{1}{\frac{1}{8} + \frac{1}{\frac{1}{16} + \frac{1}{\frac{1}{32} + \frac{1}{\frac{1}{64}}}}}}} = [1, 3, 1, 1, 4, 14, 1, 1, 1, 1, 79, 2, 1, 1, 2]$$

We used `\xintCntoGC` as we wanted to display also the continued fraction and not only the fraction returned by `\xintCntoF`.

There are also `\xintGCntoF` and `\xintGCntoGC` which allow the same for generalized fractions. The following initial portion of a generalized continued fraction for  $\pi$ :

$$\frac{92736}{29520} = \frac{4}{1 + \frac{1}{3 + \frac{4}{5 + \frac{9}{7 + \frac{16}{9 + \frac{25}{11}}}}}} = 3.1414634146 \dots$$

was obtained with this code:

```
\def\an #1{\the\numexpr 2*#1+1\relax}%
\def\bn #1{\the\numexpr (#1+1)*(#1+1)\relax}%
\[\ \xintFrac{\xintDiv {4}{\xintGCntoF {5}{\an}{\bn}}}{\cfrac{4}{\xintGCFrac{\xintGCntoGC {5}{\an}{\bn}}}} =
\xintTrunc {10}{\xintDiv {4}{\xintGCntoF {5}{\an}{\bn}}}\dots\]
```

We see that the quality of approximation is not fantastic compared to the simple continued fraction of  $\pi$  with about as many terms:

```
\[\ \xintFrac{\xintCstoF{3,7,15,1,292,1,1}}{
\xintGCFrac{3+1/7+1/15+1/1+1/292+1/1+1/1}=
\xintTrunc{10}{\xintCstoF{3,7,15,1,292,1,1}}\dots\]
```

$$\frac{208341}{66317} = 3 + \frac{1}{7 + \frac{1}{15 + \frac{1}{1 + \frac{1}{292 + \frac{1}{1 + \frac{1}{1}}}}}} = 3.1415926534 \dots$$

To conclude this overview of most of the package functionalities, let us explore the convergents of Euler's number  $e$ .

```
\def\cn #1{\the\numexpr\ifcase \numexpr #1+3-3*((#1+2)/3)\relax
1\or1\or2*(#1/3)\fi\relax }
% produces the pattern 1,1,2,1,1,4,1,1,6,1,1,8,... which are the
% coefficients of the simple continued fraction of e-1.
\cnta 0
\def\mymacro #1{\advance\cnta by 1
\noindent
\hbox to 3em {\hfil\small\texttt{\the\cnta.} }%
$\xintTrunc {30}{\xintAdd {1[0]}{#1}}\dots=
\xintFrac{\xintAdd {1[0]}{#1}}{#1}}$}%
\xintListWithSep{\vtop to 6pt}{\vbox to 12pt}{\par}
{\xintApply\mymacro{\xintnCstoCv{\xintCnstoCs {35}}{\cn}}}}
```

The volume of computation is kept minimal by the following steps:

- a comma separated list of the first 36 coefficients is produced by `\xintCnstoCs`,
- this is then given to `\xintnCstoCv` which produces the list of the convergents (there is also `\xintCstoCv`, but our coefficients being integers we used the infinitesimally faster `\xintnCstoCv`),
- then the whole list was converted into a sequence of one-line paragraphs, each convergent becomes the argument to a macro printing it together with its decimal expansion with 30 digits after the decimal point.
- A count register `\cnta` was used to give a line count serving as a visual aid: we could also have done that in an expandable way, but well, let's relax from time to time...

1.  $2.00000000000000000000000000000000 \dots = 2$
2.  $3.00000000000000000000000000000000 \dots = 3$
3.  $2.66666666666666666666666666666666 \dots = \frac{8}{3}$
4.  $2.75000000000000000000000000000000 \dots = \frac{11}{4}$
5.  $2.714285714285714285714285714285 \dots = \frac{19}{7}$
6.  $2.71875000000000000000000000000000 \dots = \frac{87}{32}$
7.  $2.717948717948717948717948717948 \dots = \frac{106}{39}$
8.  $2.718309859154929577464788732394 \dots = \frac{193}{71}$
9.  $2.718279569892473118279569892473 \dots = \frac{1264}{465}$
10.  $2.718283582089552238805970149253 \dots = \frac{1457}{536}$
11.  $2.718281718281718281718281718281 \dots = \frac{2721}{1001}$
12.  $2.718281835205992509363295880149 \dots = \frac{23225}{8544}$
13.  $2.718281822943949711891042430591 \dots = \frac{25946}{9545}$
14.  $2.718281828735695726684725523798 \dots = \frac{49171}{18089}$

15.  $2.718281828445401318035025074172 \dots = \frac{517656}{190435}$
16.  $2.718281828470583721777828930962 \dots = \frac{566827}{208524}$
17.  $2.718281828458563411277850606202 \dots = \frac{1084483}{398959}$
18.  $2.718281828459065114074529546648 \dots = \frac{13580623}{4996032}$
19.  $2.718281828459028013207065591026 \dots = \frac{14665106}{5394991}$
20.  $2.718281828459045851404621084949 \dots = \frac{28245729}{10391023}$
21.  $2.718281828459045213521983758221 \dots = \frac{410105312}{150869313}$
22.  $2.718281828459045254624795027092 \dots = \frac{438351041}{161260336}$
23.  $2.718281828459045234757560631479 \dots = \frac{848456353}{312129649}$
24.  $2.718281828459045235379013372772 \dots = \frac{14013652689}{5155334720}$
25.  $2.718281828459045235343535532787 \dots = \frac{14862109042}{5467464369}$
26.  $2.718281828459045235360753230188 \dots = \frac{28875761731}{10622799089}$
27.  $2.718281828459045235360274593941 \dots = \frac{534625820200}{196677847971}$
28.  $2.718281828459045235360299120911 \dots = \frac{563501581931}{207300647060}$
29.  $2.718281828459045235360287179900 \dots = \frac{1098127402131}{403978495031}$
30.  $2.718281828459045235360287478611 \dots = \frac{22526049624551}{8286870547680}$
31.  $2.718281828459045235360287464726 \dots = \frac{23624177026682}{8690849042711}$
32.  $2.718281828459045235360287471503 \dots = \frac{46150226651233}{16977719590391}$
33.  $2.718281828459045235360287471349 \dots = \frac{1038929163353808}{382200680031313}$
34.  $2.718281828459045235360287471355 \dots = \frac{1085079390005041}{399178399621704}$
35.  $2.718281828459045235360287471352 \dots = \frac{2124008553358849}{781379079653017}$
36.  $2.718281828459045235360287471352 \dots = \frac{52061284670617417}{19152276311294112}$

The actual computation of the list of all 36 convergents accounts for only 8% of the total time (total time equal to about 5 hundredths of a second in my testing, on my laptop): another 80% is occupied with the computation of the truncated decimal expansions (and the addition of 1 to everything as the formula gives the continued fraction of  $e - 1$ ). One can with no problem compute much bigger convergents. Let's get the 200th convergent. It turns out to have the same first 268 digits after the decimal point as  $e - 1$ . Higher convergents get more and more digits in proportion to their index: the 500th convergent already gets 799 digits correct! To allow speedy compilation of the source of this document when the need arises, I limit here to the 200th convergent (getting the 500th took about 1.2s on my laptop last time I tried, and the 200th convergent is obtained ten times faster).

```
\edef\z {\xintCnToF {199}{\cn}}%
\begingroup\parindent 0pt \leftskip 2.5cm
\indent\llap {Numerator = }\printnumber{\xintNumerator\z}\par
\indent\llap {Denominator = }\printnumber{\xintDenominator\z}\par
\indent\llap {Expansion = }\printnumber{\xintTrunc{268}\z}\dots
\par\endgroup
```

```

Numerator = 56896403887189626759752389231580787529388901766791744605
              72320245471922969611182301752438601749953108177313670124
              1708609749634329382906
Denominator = 33112381766973761930625636081635675336546882372931443815
              62056154632466597285818654613376920631489160195506145705
              9255337661142645217223
Expansion = 1.718281828459045235360287471352662497757247093699959574
              96696762772407663035354759457138217852516642742746639193
              20030599218174135966290435729003342952605956307381323286
              27943490763233829880753195251019011573834187930702154089
              1499348841675092447614606680822648001684774118...

```

One can also use a centered continued fraction: we get more digits but there are also more computations as the numerators may be either 1 or  $-1$ .

### 34.2 `\xintCFrac`

**Frac**  
*f* ★ `\xintCFrac{f}` is a math-mode only,  $\text{\LaTeX}$  with `amsmath` only, macro which first computes then displays with the help of `\cfrac` the simple continued fraction corresponding to the given fraction (or macro expanding in two steps to one such). It admits an optional argument which may be `[l]`, `[r]` or (the default) `[c]` to specify the location of the one's in the numerators of the sub-fractions. Each coefficient is typeset using the `\xintFrac` macro from the **xintcf** package.

### 34.3 `\xintGCFrac`

*f* ★ `\xintGCFrac{a+b/c+d/e+f/g+h/...}` uses similarly `\cfrac` to typeset a generalized continued fraction in inline format. It admits the same optional argument as `\xintCFrac`.  
`\[\xintGCFrac {1+\xintPow{1.5}{3}/{1/7}+{-3/5}/\xintFac {6}}\]`

$$1 + \frac{3375 \cdot 10^{-3}}{\frac{1}{7} - \frac{\frac{3}{5}}{720}}$$

As can be seen this is typesetting macro, although it does proceed to the evaluation of the coefficients themselves. See `\xintGctoF` if you are impatient to see this fraction computed. Numerators and denominators are made arguments to the `\xintFrac` macro.

### 34.4 `\xintGctoGCx`

*nnf* ★ `\xintGctoGCx{sepa}{sepb}{a+b/c+d/e+f/...+x/y}` returns the list of the coefficients of the generalized continued fraction of `f`, each one within a pair of braces, and separated with the help of `sepa` and `sepb`. Thus

`\xintGctoGCx :;{1+2/3+4/5+6/7}` gives `1:2;3:4;5:6;7`

Plain  $\text{\TeX}$ +`amstex` users may be interested in:

```

$$\xintGctoGCx {+\cfrac}{\\}{a+b/...}\endcfrac$$
$$\xintGctoGCx {+\cfrac\xintFwOver}{\\ \xintFwOver}{a+b/...}\endcfrac$$

```

**34.5 \xintFtoCs**

$\frac{\text{Frac}}{f}$  ★ `\xintFtoCs{f}` returns the comma separated list of the coefficients of the simple continued fraction of  $f$ .

`\[ \xintSignedFrac{-5262046/89233} = [\xintFtoCs{-5262046/89233}]\]`

$$-\frac{5262046}{89233} = [-59, 33, 27, 100]$$

**34.6 \xintFtoCx**

$\frac{\text{Frac}}{n f}$  ★ `\xintFtoCx{sep}{f}` returns the list of the coefficients of the simple continued fraction of  $f$ , withing group braces and separated with the help of `sep`.

`$$\xintFtoCx {+\cfrac1{\ }}{f}\endcfrac$$`

will display the continued fraction in `\cfrac` format, with Plain  $\text{\TeX}$  and `amstex`.

**34.7 \xintFtoGC**

$\frac{\text{Frac}}{f}$  ★ `\xintFtoGC{f}` does the same as `\xintFtoCx{+1/}{f}`. Its output may thus be used in the package macros expecting such an ‘inline format’. This continued fraction is a *simple* one, not a *generalized* one, but as it is produced in the format used for user input of generalized continued fractions, the macro was called `\xintFtoGC` rather than `\xintFtoC` for example.

`566827/208524=\xintFtoGC {566827/208524}`

`566827/208524=2+1/1+1/2+1/1+1/1+1/4+1/1+1/1+1/6+1/1+1/1+1/8+1/1+1/1+1/11`

**34.8 \xintFtoCC**

$\frac{\text{Frac}}{f}$  ★ `\xintFtoCC{f}` returns the ‘centered’ continued fraction of  $f$ , in ‘inline format’.

`566827/208524=\xintFtoCC {566827/208524}`

`566827/208524=3+-1/4+-1/2+1/5+-1/2+1/7+-1/2+1/9+-1/2+1/11`

`\[ \xintFrac{566827/208524} = \xintGCFrac{\xintFtoCC{566827/208524}} \]`

$$\frac{566827}{208524} = 3 - \frac{1}{4 - \frac{1}{2 + \frac{1}{5 - \frac{1}{2 + \frac{1}{7 - \frac{1}{2 + \frac{1}{9 - \frac{1}{2 + \frac{1}{11}}}}}}}}}$$

**34.9 \xintFtoCv**

$\frac{\text{Frac}}{f}$  ★ `\xintFtoCv{f}` returns the list of the (braced) convergents of  $f$ , with no separator. To be

treated with `\xintAssignArray` or `\xintListWithSep`.

`\[\xintListWithSep{\to}{\xintApply\xintFrac{\xintFtoCv{5211/3748}}}\]`

$$1 \rightarrow \frac{3}{2} \rightarrow \frac{4}{3} \rightarrow \frac{7}{5} \rightarrow \frac{25}{18} \rightarrow \frac{32}{23} \rightarrow \frac{57}{41} \rightarrow \frac{317}{228} \rightarrow \frac{374}{269} \rightarrow \frac{691}{497} \rightarrow \frac{5211}{3748}$$

### 34.10 `\xintFtoCCv`

*Frac*  
*f* ★

`\xintFtoCCv{f}` returns the list of the (braced) centered convergents of *f*, with no separator. To be treated with `\xintAssignArray` or `\xintListWithSep`.

`\[\xintListWithSep{\to}{\xintApply\xintFrac{\xintFtoCCv{5211/3748}}}\]`

$$1 \rightarrow \frac{4}{3} \rightarrow \frac{7}{5} \rightarrow \frac{32}{23} \rightarrow \frac{57}{41} \rightarrow \frac{374}{269} \rightarrow \frac{691}{497} \rightarrow \frac{5211}{3748}$$

### 34.11 `\xintCstoF`

*f* ★ `\xintCstoF{a,b,c,d,...,z}` computes the fraction corresponding to the coefficients, which may be fractions or even macros expanding to such fractions (in two steps). The final fraction may then be highly reducible.

`\[\xintGCFrac {-1+1/3+1/-5+1/7+1/-9+1/11+1/-13}`

`=\xintSignedFrac{\xintCstoF {-1,3,-5,7,-9,11,-13}}`

`=\xintSignedFrac{\xintGctoF {-1+1/3+1/-5+1/7+1/-9+1/11+1/-13}}\]`

$$-1 + \frac{1}{3 + \frac{1}{-5 + \frac{1}{7 + \frac{1}{-9 + \frac{1}{11 + \frac{1}{-13}}}}}} = -\frac{75887}{118187} = -\frac{75887}{118187}$$

`\xintGCFrac{{1/2}+1/{1/3}+1/{1/4}+1/{1/5}}=`  
`\xintFrac{\xintCstoF {1/2,1/3,1/4,1/5}}`

$$\frac{1}{2} + \frac{1}{\frac{1}{\frac{1}{\frac{1}{\frac{1}{3} + \frac{1}{\frac{1}{\frac{1}{4} + \frac{1}{\frac{1}{5}}}}}}}} = \frac{159}{66}$$

A generalized continued fraction may produce a reducible fraction (`\xintCstoF` tries its best not to accumulate in a silly way superfluous factors but will not do simplifications which would be obvious to a human, like simplification by 3 in the result above).

### 34.12 `\xintCstoCv`

*f* ★ `\xintCstoCv{a,b,c,d,...,z}` returns the list of the corresponding convergents. It is al-

lowed to use fractions as coefficients (the computed convergents have then no reason to be the real convergents of the final fraction). When the coefficients are integers, the convergents are irreducible fractions, but otherwise it is not necessarily the case.

```
\xintListWithSep:{\xintCstoCv{1,2,3,4,5,6}}
1/1:3/2:10/7:43/30:225/157:1393/972
\xintListWithSep:{\xintCstoCv{1,1/2,1/3,1/4,1/5,1/6}}
1/1:3/1:9/7:45/19:225/159:1575/729
\[\xintListWithSep{\to}{\xintApply\xintFrac{\xintCstoCv
{\xintPow{-.3}{-5},7.3/4.57,\xintCstoF{3/4,9,-1/3}}}}\]

$$\frac{-100000}{243} \rightarrow \frac{-72888949}{177390} \rightarrow \frac{-2700356878}{6567804}$$

```

### 34.13 **\xintCstoGC**

*f*★ **\xintCstoGC**{a,b,...,z} transforms a comma separated list (or something expanding to such a list) into an ‘inline format’ continued fraction {a}+1/{b}+1/...+1/{z}. The coefficients are just copied and put within braces, without expansion. The output can then be used in **\xintGCFrac** for example.

```
\[\xintGCFrac {\xintCstoGC {-1,1/2,-1/3,1/4,-1/5}}
=\xintSignedFrac {\xintCstoF {-1,1/2,-1/3,1/4,-1/5}}\]
```

$$-1 + \frac{1}{\frac{1}{2} + \frac{1}{\frac{-1}{3} + \frac{1}{\frac{1}{4} + \frac{1}{\frac{-1}{5}}}}} = -\frac{145}{83}$$

### 34.14 **\xintGctoF**

*f*★ **\xintGctoF**{a+b/c+d/e+f/g+...+v/w+x/y} computes the fraction defined by the inline generalized continued fraction. Coefficients may be fractions but must then be put within braces. They can be macros. The plus signs are mandatory.

```
\[\xintGCFrac {1+\xintPow{1.5}{3}/{1/7}+{-3/5}/\xintFac {6}} =
\xintFrac{\xintGctoF {1+\xintPow{1.5}{3}/{1/7}+{-3/5}/\xintFac {6}}} =
\xintFrac{\xintIrr{\xintGctoF
{1+\xintPow{1.5}{3}/{1/7}+{-3/5}/\xintFac {6}}}}\]
```

$$1 + \frac{3375 \cdot 10^{-3}}{\frac{1}{7} - \frac{3}{720}} = \frac{88629000}{3579000} = \frac{29543}{1193}$$

```
\[ \xintGCFrac{{1/2}+{2/3}/{4/5}+{1/2}/{1/5}+{3/2}/{5/3}} =
\xintFrac{\xintGctoF {{1/2}+{2/3}/{4/5}+{1/2}/{1/5}+{3/2}/{5/3}}} \]
```

$$\frac{1}{2} + \frac{\frac{2}{3}}{\frac{4}{5} + \frac{\frac{1}{2}}{\frac{1}{5} + \frac{3}{5}}}} = \frac{4270}{4140}$$

The macro tries its best not to accumulate superfluous factor in the denominators, but doesn't reduce the fraction to irreducible form before returning it and does not do simplifications which would be obvious to a human.

### 34.15 **\xintGtoCv**

$f$  ★ **\xintGtoCv**{a+b/c+d/e+f/g+...+v/w+x/y} returns the list of the corresponding convergents. The coefficients may be fractions, but must then be inside braces. Or they may be macros, too.

The convergents will in the general case be reducible. To put them into irreducible form, one needs one more step, for example it can be done with **\xintApply\xintIrr**.

```
\[\xintListWithSep{,}{\xintApply\xintFrac
    {\xintGtoCv{3+{-2}/{7/2}+{3/4}/12+{-56}/3}}}\]
\[\xintListWithSep{,}{\xintApply\xintFrac{\xintApply\xintIrr
    {\xintGtoCv{3+{-2}/{7/2}+{3/4}/12+{-56}/3}}}}\]
```

$$3, \frac{17}{7}, \frac{834}{342}, \frac{1306}{542}$$

$$3, \frac{17}{7}, \frac{139}{57}, \frac{653}{271}$$

### 34.16 **\xintCntoF**

$\overset{\text{num}}{x}$   $f$  ★ **\xintCntoF**{N}{\macro} computes the fraction  $f$  having coefficients  $c(j)=\text{\macro}\{j\}$  for  $j=0, 1, \dots, N$ . The  $N$  parameter is given to a **\numexpr**. The values of the coefficients, as returned by **\macro** do not have to be positive, nor integers, and it is thus not necessarily the case that the original  $c(j)$  are the true coefficients of the final  $f$ .

```
\def\macro #1{\the\numexpr 1+#1*#1\relax}\xintCntoF {5}{\macro}
72625/49902 [0]
```

### 34.17 **\xintGCntoF**

$\overset{\text{num}}{x}$   $ff$  ★ **\xintGCntoF**{N}{\macroA}{\macroB} returns the fraction  $f$  corresponding to the inline generalized continued fraction  $a_0+b_0/a_1+b_1/a_2+\dots+b(N-1)/a_N$ , with  $a(j)=\text{\macroA}\{j\}$  and  $b(j)=\text{\macroB}\{j\}$ . The  $N$  parameter is given to a **\numexpr**.

$$1 + \frac{1}{2 - \frac{1}{3 + \frac{1}{1 - \frac{1}{2 + \frac{1}{3 - \frac{1}{1}}}}}} = \frac{39}{25}$$

There is also **\xintGCntoGC** to get the ‘inline format’ continued fraction. The previous display was obtained with:

```
\def\coeffA #1{\the\numexpr #1+4-3*((#1+2)/3)\relax }%
```

```

\def\coeffB #1{\xintMON{#1}}% (-1)^n
\[\xintGCFrac{\xintGCntoGC {6}{\coeffA}{\coeffB}}
= \xintFrac{\xintGCntoF {6}{\coeffA}{\coeffB}}\]

```

**34.18 \xintCtoCs**

$\overset{\text{num}}{x} f \star$  `\xintCtoCs{N}{\macro}` produces the comma separated list of the corresponding coefficients, from  $n=0$  to  $n=N$ . The  $N$  is given to a `\numexpr`.

```

\def\macro #1{\the\numexpr 1+#1*#1\relax}
\xintCtoCs {5}{\macro}->1,2,5,10,17,26
\[\xintFrac{\xintCtoF {5}{\macro}}=\xintCfrac{\xintCtoF {5}{\macro}}\]

```

$$\frac{72625}{49902} = 1 + \frac{1}{2 + \frac{1}{5 + \frac{1}{10 + \frac{1}{17 + \frac{1}{26}}}}}$$

**34.19 \xintCtoGC**

$\overset{\text{num}}{x} f \star$  `\xintCtoGC{N}{\macro}` evaluates the  $c(j)=\macro{j}$  from  $j=0$  to  $j=N$  and returns a continued fraction written in inline format:  $\{c(0)\}+1/\{c(1)\}+1/\dots+1/\{c(N)\}$ . The parameter  $N$  is given to a `\numexpr`. The coefficients, after expansion, are, as shown, being enclosed in an added pair of braces, they may thus be fractions.

```

\def\macro #1{\the\numexpr\ifodd#1 -1-#1\else1+#1\fi\relax}%
\the\numexpr 1+#1*#1\relax}
\edef\x{\xintCtoGC {5}{\macro}}\meaning\x
macro:->\{1/1\}+1/{-2/2}+1/{3/5}+1/{-4/10}+1/{5/17}+1/{-6/26}
\[\xintGCFrac{\xintCtoGC {5}{\macro}}\]

```

$$1 + \frac{1}{\frac{-2}{2} + \frac{1}{\frac{3}{5} + \frac{1}{\frac{-4}{10} + \frac{1}{\frac{5}{17} + \frac{1}{\frac{-6}{26}}}}}}$$

**34.20 \xintGCtoGC**

$\overset{\text{num}}{x} ff \star$  `\xintGCtoGC{N}{\macroA}{\macroB}` evaluates the coefficients and then returns the corresponding  $\{a_0\}+\{b_0\}/\{a_1\}+\{b_1\}/\{a_2\}+\dots+\{b(N-1)\}/\{a_N\}$  inline generalized fraction.  $N$  is given to a `\numexpr`. As shown, the coefficients are enclosed into added pairs of braces, and may thus be fractions.

```

#1*#1*#1+1\relax}%

```

```
\def\bn #1{\the\numexpr \xintiiMON{#1}*(#1+1)\relax}%
$\xintGCntoGC {5}{\an}{\bn}}=\xintGCFrac {\xintGCntoGC {5}{\an}{\bn}} =
\displaystyle\xintFrac {\xintGCntoF {5}{\an}{\bn}}$\par
```

$$1 + 1/2 + -2/9 + 3/28 + -4/65 + 5/126 = 1 + \frac{1}{2 - \frac{3}{9 + \frac{4}{28 - \frac{5}{65 + \frac{5}{126}}}}} = \frac{5797655}{3712466}$$

### 34.21 `\xintiCstoF`, `\xintiGctoF`, `\xintiCstoCv`, `\xintiGctoCv`

The same as the corresponding macros without the ‘i’, but for integer-only input. Infinitely faster; to notice the higher efficiency one would need to use them with an input having (at least) hundreds of coefficients.

### 34.22 `\xintGctoGC`

*f* ★ `\xintGctoGC{a+b/c+d/e+f/g+.....+v/w+x/y}` expands (with the usual meaning) each one of the coefficients and returns an inline continued fraction of the same type, each expanded coefficient being enclosed withing braces.

```
{6}+\xintCstoF {2,-7,-5}/16}} \meaning\x
macro:->{1}+{3375/1[-3]}/{1/7}+{-3/5}/{720}+{67/36}/{16}
```

To be honest I have, it seems, forgotten why I wrote this macro in the first place.

## 35 Package **xinttools** implementation

Release 1.09g splits off `xinttools.sty` from `xint.sty`.

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### 35.1 Catcodes, $\varepsilon$ -TeX and reload detection

The method for package identification and reload detection is copied verbatim from the packages by HEIKO OBERDIEK (with some modifications starting with release 1.09b).

The method for catcodes was also inspired by these packages, we proceed slightly differently.

Starting with version 1.06 of the package, also ‘ must be catcode-protected, because we replace everywhere in the code the twice-expansion done with `\expandafter` by the systematic use of `\romannumeral-‘0`.

Starting with version 1.06b I decide that I suffer from an indigestion of @ signs, so I replace them all with underscores `_`, à la L<sup>A</sup>T<sub>E</sub>X3.

Release 1.09b is more economical: some macros are defined already in `xint.sty` (now `xinttools.sty`) and re-used in other modules. All catcode changes have been unified and `\XINT_storecatcodes` will be used by each module to redefine `\XINT_restorecatcodes_endinput` in case catcodes have changed in-between the loading of `xint.sty` (now `xinttools.sty`) and the module (not very probable but...).

```
1 \begingroup\catcode61\catcode48\catcode32=10\relax%
2 \catcode13=5 % ^^M
```

```

3  \endlinechar=13 %
4  \catcode123=1   % {
5  \catcode125=2   % }
6  \catcode64=11   % @
7  \catcode95=11   % _
8  \catcode35=6    % #
9  \catcode44=12   % ,
10 \catcode45=12   % -
11 \catcode46=12   % .
12 \catcode58=12   % :
13 \expandafter\let\expandafter\x\csname ver@xint.sty\endcsname
14 \expandafter
15   \ifx\csname PackageInfo\endcsname\relax
16     \def\y#1#2{\immediate\write-1{Package #1 Info: #2.}}%
17   \else
18     \def\y#1#2{\PackageInfo{#1}{#2}}%
19   \fi
20 \expandafter
21 \ifx\csname numexpr\endcsname\relax
22   \y{xinttools}{\numexpr not available, aborting input}%
23   \aftergroup\endinput
24 \else
25   \ifx\x\relax % plain-TeX, first loading
26   \else
27     \def\empty {}%
28     \ifx\x\empty % LaTeX, first loading,
29     % variable is initialized, but \ProvidesPackage not yet seen
30   \else
31     \y{xinttools}{I was already loaded, aborting input}%
32     \aftergroup\endinput
33   \fi
34 \fi
35 \fi
36 \def\ChangeCatcodesIfInputNotAborted
37 {%
38   \endgroup
39   \def\XINT_storecatcodes
40   {% takes care of all, to allow more economical code in modules
41     \catcode63=\the\catcode63 % ? xintexpr
42     \catcode124=\the\catcode124 % | xintexpr
43     \catcode38=\the\catcode38 % & xintexpr
44     \catcode64=\the\catcode64 % @ xintexpr
45     \catcode33=\the\catcode33 % ! xintexpr
46     \catcode93=\the\catcode93 % ] -, xintfrac, xintseries, xintcfrac
47     \catcode91=\the\catcode91 % [ -, xintfrac, xintseries, xintcfrac
48     \catcode36=\the\catcode36 % $ xintgcd only
49     \catcode94=\the\catcode94 % ^
50     \catcode96=\the\catcode96 % '
51     \catcode47=\the\catcode47 % /

```

```

52      \catcode41=\the\catcode41    % )
53      \catcode40=\the\catcode40    % (
54      \catcode42=\the\catcode42    % *
55      \catcode43=\the\catcode43    % +
56      \catcode62=\the\catcode62    % >
57      \catcode60=\the\catcode60    % <
58      \catcode58=\the\catcode58    % :
59      \catcode46=\the\catcode46    % .
60      \catcode45=\the\catcode45    % -
61      \catcode44=\the\catcode44    % ,
62      \catcode35=\the\catcode35    % #
63      \catcode95=\the\catcode95    % _
64      \catcode125=\the\catcode125  % }
65      \catcode123=\the\catcode123  % {
66      \endlinechar=\the\endlinechar
67      \catcode13=\the\catcode13    % ^^M
68      \catcode32=\the\catcode32    %
69      \catcode61=\the\catcode61\relax    % =
70  }%
71  \edef\XINT_restorecatcodes_endinput
72  {%
73      \XINT_storecatcodes\noexpand\endinput %
74  }%
75  \def\XINT_setcatcodes
76  {%
77      \catcode61=12    % =
78      \catcode32=10    % space
79      \catcode13=5     % ^^M
80      \endlinechar=13 %
81      \catcode123=1    % {
82      \catcode125=2    % }
83      \catcode95=11    % _ (replaces @ everywhere, starting with 1.06b)
84      \catcode35=6     % #
85      \catcode44=12    % ,
86      \catcode45=12    % -
87      \catcode46=12    % .
88      \catcode58=11    % : (made letter for error cs)
89      \catcode60=12    % <
90      \catcode62=12    % >
91      \catcode43=12    % +
92      \catcode42=12    % *
93      \catcode40=12    % (
94      \catcode41=12    % )
95      \catcode47=12    % /
96      \catcode96=12    % ' (for ubiquitous \romannumeral-'0 and some \catcode )
97      \catcode94=11    % ^
98      \catcode36=3     % $
99      \catcode91=12    % [
100     \catcode93=12    % ]

```

```

101      \catcode33=11 % !
102      \catcode64=11 % @
103      \catcode38=12 % &
104      \catcode124=12 % |
105      \catcode63=11 % ?
106      }%
107      \XINT_setcatcodes
108  }%
109 \ChangeCatcodesIfInputNotAborted
110 \def\XINTsetupcatcodes {% for use by other modules
111      \edef\XINT_restorecatcodes_endinput
112      {%
113          \XINT_storecatcodes\noexpand\endinput %
114      }%
115      \XINT_setcatcodes
116 }%

```

### 35.2 Package identification

Inspired from HEIKO OBERDIEK's packages. Modified in 1.09b to allow re-use in the other modules. Also I assume now that if `\ProvidesPackage` exists it then does define `\ver@<pkgname>.sty`, code of H0 for some reason escaping me (compatibility with LaTeX 2.09 or other things ??) seems to set extra precautions.

1.09c uses e-TeX `\ifdefined`.

```

117 \ifdefined\ProvidesPackage
118   \let\XINT_providespackage\relax
119 \else
120   \def\XINT_providespackage #1#2[#3]%
121       {\immediate\write-1{Package: #2 #3}%
122        \expandafter\xdef\csname ver@#2.sty\endcsname{#3}}%
123 \fi
124 \XINT_providespackage
125 \ProvidesPackage {xinttools}%
126 [2014/01/09 v1.09j Expandable and non-expandable utilities (jfb)]%

```

### 35.3 Token management, constants

In 1.09e `\xint_undef` replaced everywhere by `\xint_bye`. Release 1.09h makes most everything `\long`.

```

127 \long\def\xint_gobble_      {}%
128 \long\def\xint_gobble_i    #1{}%
129 \long\def\xint_gobble_ii   #1#2{}%
130 \long\def\xint_gobble_iii  #1#2#3{}%
131 \long\def\xint_gobble_iv   #1#2#3#4{}%
132 \long\def\xint_gobble_v    #1#2#3#4#5{}%
133 \long\def\xint_gobble_vi   #1#2#3#4#5#6{}%
134 \long\def\xint_gobble_vii  #1#2#3#4#5#6#7{}%

```

```

135 \long\def\xint_gobble_viii #1#2#3#4#5#6#7#8{}%
136 \long\def\xint_firstofone #1{#1}%
137 \xint_firstofone{\let\xint_sptoken= } %<- space here!
138 \long\def\xint_firstoftwo #1#2{#1}%
139 \long\def\xint_secondoftwo #1#2{#2}%
140 \long\def\xint_firstoftwo_thenstop #1#2{ #1}%
141 \long\def\xint_secondoftwo_thenstop #1#2{ #2}%
142 \def\xint_minus_thenstop { -}%
143 \long\def\xint_gob_til_R #1\R {}%
144 \long\def\xint_gob_til_W #1\W {}%
145 \long\def\xint_gob_til_Z #1\Z {}%
146 \long\def\xint_bye #1\xint_bye {}%
147 \let\xint_relax\relax
148 \def\xint_brelax {\xint_relax}%
149 \long\def\xint_gob_til_xint_relax #1\xint_relax {}%
150 \long\def\xint_afterfi #1#2\fi {\fi #1}%
151 \chardef\xint_c_ 0
152 \chardef\xint_c_viii 8
153 \newtoks\xint_toks

```

### 35.4 \xintodef, \xintgodef, \odef

1.09i. For use in \xintAssign. No parameter text! 1.09j uses \xint... rather than \XINT.... \xintAssign [o] will use the preexisting \odef if there was one before xint' loading.

```

154 \def\xintodef #1{\expandafter\def\expandafter#1\expandafter}%
155 \ifdefined\odef\else\let\odef\xintodef\fi
156 \def\xintgodef {\global\xintodef}%

```

### 35.5 \xintoodef, \xintgoodef, \oodef

1.09i. Can be prefixed with \global. No parameter text. The alternative \def\oodef #1#{\def\XINT\_tmpa{#1}

```

\expandafter\expandafter\expandafter\expandafter
\expandafter\expandafter\expandafter\def
\expandafter\expandafter\expandafter\XINT_tmpa
\expandafter\expandafter\expandafter}

```

could not be prefixed by \global. Anyhow, macro parameter tokens would have to somehow not be seen by expanded stuff, except if designed for it. \xintAssign [oo] (etc...) uses the pre-existing \oodef if there was one.

```

157 \def\xintoodef #1{\expandafter\expandafter\expandafter\def
158 \expandafter\expandafter\expandafter#1%
159 \expandafter\expandafter\expandafter}%
160 \ifdefined\oodef\else\let\oodef\xintoodef\fi
161 \def\xintgoodef {\global\xintoodef}%

```

**35.6 \xintfdef, \xintgfdef, \fdef**

1.09i. No parameter text!

```
162 \def\xintfdef #1#2{\expandafter\def\expandafter#1\expandafter
163      {\romannumeral-‘0#2}}}%
164 \ifdefined\fdef\else\let\fdef\xintfdef\fi
165 \def\xintgfdef {\global\xintfdef }% should be \global\fdef if \fdef pre-exists?
```

**35.7 \xintReverseOrder**

\xintReverseOrder: does NOT expand its argument.

```
166 \def\xintReverseOrder {\romannumeral0\xintreverseorder }%
167 \long\def\xintreverseorder #1%
168 {%
169     \XINT_rord_main {}#1%
170     \xint_relax
171     \xint_bye\xint_bye\xint_bye\xint_bye
172     \xint_bye\xint_bye\xint_bye\xint_bye
173     \xint_relax
174 }%
175 \long\def\XINT_rord_main #1#2#3#4#5#6#7#8#9%
176 {%
177     \xint_bye #9\XINT_rord_cleanup\xint_bye
178     \XINT_rord_main {#9#8#7#6#5#4#3#2#1}%
179 }%
180 \long\edef\XINT_rord_cleanup\xint_bye\XINT_rord_main #1#2\xint_relax
181 {%
182     \noexpand\expandafter\space\noexpand\xint_gob_til_xint_relax #1%
183 }%
```

**35.8 \xintRevWithBraces**

New with 1.06. Makes the expansion of its argument and then reverses the resulting tokens or braced tokens, adding a pair of braces to each (thus, maintaining it when it was already there).

As in some other places, 1.09e replaces \Z by \xint\_bye, although here it is just for coherence of notation as \Z would be perfectly safe. The reason for \xint\_relax, here and in other locations, is in case #1 expands to nothing, the \romannumeral-‘0 must be stopped

```
184 \def\xintRevWithBraces {\romannumeral0\xintrevwithbraces }%
185 \def\xintRevWithBracesNoExpand {\romannumeral0\xintrevwithbracesnoexpand }%
186 \long\def\xintrevwithbraces #1%
187 {%
188     \expandafter\XINT_revwbr_loop\expandafter{\expandafter}%
189     \romannumeral-‘0#1\xint_relax\xint_relax\xint_relax\xint_relax
190     \xint_relax\xint_relax\xint_relax\xint_relax\xint_bye
```

```

191 }%
192 \long\def\xintrevwithbracesnoexpand #1%
193 {%
194     \XINT_revwbr_loop {}%
195     #1\xint_relax\xint_relax\xint_relax\xint_relax
196     \xint_relax\xint_relax\xint_relax\xint_relax\xint_bye
197 }%
198 \long\def\XINT_revwbr_loop #1#2#3#4#5#6#7#8#9%
199 {%
200     \xint_gob_til_xint_relax #9\XINT_revwbr_finish_a\xint_relax
201     \XINT_revwbr_loop {{#9}{{#8}}{{#7}}{{#6}}{{#5}}{{#4}}{{#3}}{{#2}}#1}%
202 }%
203 \long\def\XINT_revwbr_finish_a\xint_relax\XINT_revwbr_loop #1#2\xint_bye
204 {%
205     \XINT_revwbr_finish_b #2\R\R\R\R\R\R\R\Z #1%
206 }%
207 \def\XINT_revwbr_finish_b #1#2#3#4#5#6#7#8\Z
208 {%
209     \xint_gob_til_R
210         #1\XINT_revwbr_finish_c 8%
211         #2\XINT_revwbr_finish_c 7%
212         #3\XINT_revwbr_finish_c 6%
213         #4\XINT_revwbr_finish_c 5%
214         #5\XINT_revwbr_finish_c 4%
215         #6\XINT_revwbr_finish_c 3%
216         #7\XINT_revwbr_finish_c 2%
217         \R\XINT_revwbr_finish_c 1\Z
218 }%
219 \def\XINT_revwbr_finish_c #1#2\Z
220 {%
221     \expandafter\expandafter\expandafter
222         \space
223     \csname xint_gobble_\romannumeral #1\endcsname
224 }%
```

### 35.9 \xintLength

`\xintLength` does NOT expand its argument.

1.09g adds the missing `\xintlength`, which was previously called `\XINT_length`, and suppresses `\XINT_Length`

1.06: improved code is roughly 20% faster than the one from earlier versions.

1.09a, \xintnum inserted. 1.09e: \Z->\xint\_bye as this is called from \xint-NthElt, and there it was necessary not to use \Z. Later use of \Z and \W perfectly safe here.

```

225 \def\xintLength {\romannumeral0\xintlength}%
226 \long\def\xintlength #1%
227 {%
228     \XINT_length_loop

```

```

229 {0}#1\xint_relax\xint_relax\xint_relax\xint_relax
230 \xint_relax\xint_relax\xint_relax\xint_relax\xint_bye
231 }%
232 \long\def\XINT_length_loop #1#2#3#4#5#6#7#8#9%
233 {%
234 \xint_gob_til_xint_relax #9\XINT_length_finish_a\xint_relax
235 \expandafter\XINT_length_loop\expandafter {\the\numexpr #1+8\relax}%
236 }%
237 \def\XINT_length_finish_a\xint_relax
238 \expandafter\XINT_length_loop\expandafter #1#2\xint_bye
239 {%
240 \XINT_length_finish_b #2\W\W\W\W\W\W\W\Z {#1}%
241 }%
242 \def\XINT_length_finish_b #1#2#3#4#5#6#7#8\Z
243 {%
244 \xint_gob_til_W
245 #1\XINT_length_finish_c 8%
246 #2\XINT_length_finish_c 7%
247 #3\XINT_length_finish_c 6%
248 #4\XINT_length_finish_c 5%
249 #5\XINT_length_finish_c 4%
250 #6\XINT_length_finish_c 3%
251 #7\XINT_length_finish_c 2%
252 \W\XINT_length_finish_c 1\Z
253 }%
254 \edef\XINT_length_finish_c #1#2\Z #3%
255 {\noexpand\expandafter\space\noexpand\the\numexpr #3-#1\relax}%

```

### 35.10 \xintZapFirstSpaces

1.09f, written [2013/11/01].

```
256 \def\xintZapFirstSpaces {\romannumeral0\xintzapfirstspaces }%
```

defined via an \edef in order to inject space tokens inside.

```

257 \long\edef\xintzapfirstspaces #1%
258 {\noexpand\XINT_zapbsp_a \space #1\space\space\noexpand\xint_bye\xint_relax }%
259 \xint_firstofone {\long\def\XINT_zapbsp_a #1 } %<- space token here
260 {%

```

If the original #1 started with a space, here #1 will be in fact empty, so the effect will be to remove precisely one space from the original, because the first two space tokens are matched to the ones of the macro parameter text. If the original #1 did not start with a space then the #1 will be this original #1, with its added first space, up to the first <sp><sp> found. The added initial space will stop later the \romannumeral0. And in \xintZapLastSpaces we also carried along a space in order to be able to mix the two codes in \xintZapSpaces. Testing for \emptiness of #1 is NOT done with an \if test because #1 may contain \if, \fi things (one could

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use a `\detokenize` method), and also because `xint.sty` has a style of its own for doing these things...

```
261 \XINT_zapbsp_again? #1\xint_bye\XINT_zapbsp_b {#1}%
```

The `#1` above is thus either empty, or it starts with a (char 32) space token followed with a non (char 32) space token and at any rate `#1` is protected from brace stripping. It is assumed that the initial input does not contain space tokens of other than 32 as character code.

```
262 }%
```

```
263 \long\def\XINT_zapbsp_again? #1{\xint_bye #1\XINT_zapbsp_again }%
```

In the "empty" situation above, here `#1=\xint_bye`, else `#1` could be some brace things, but unbracing will anyhow not reveal any `\xint_bye`. When we do below `\XINT_zapbsp_again` we recall that we have stripped two spaces out of `<sp><original #1>`, so we have one `<sp>` less in `#1`, and when we loop we better not forget to re-insert one initial `<sp>`.

```
264 \edef\XINT_zapbsp_again\XINT_zapbsp_b #1{\noexpand\XINT_zapbsp_a\space }%
```

We now have now gotten rid of the initial spaces, but `#1` perhaps extend only to some initial chunk which was delimited by `<sp><sp>`.

```
265 \long\def\XINT_zapbsp_b #1#2\xint_relax
```

```
266 {\XINT_zapbsp_end? #2\XINT_zapbsp_e\empty #2{#1}}%
```

If the initial chunk up to `<sp><sp>` (after stripping away the first spaces) was maximal, then `#2` above is some spaces followed by `\xint_bye`, so in the `\XINT_zapbsp_end?` below it appears as `\xint_bye`, else the `#1` below will not be nor give rise after brace removal to `\xint_bye`. And then the original `\xint_bye` in `#2` will have the effect that all is swallowed and we continue with `\XINT_zapbsp_e`. If the chunk was maximal, then the `#2` above contains as many space tokens as there were originally at the end.

```
267 \long\def\XINT_zapbsp_end? #1{\xint_bye #1\XINT_zapbsp_end }%
```

The `#2` starts with a space which stops the `\romannumeral`. The `#1` contains the same number of space tokens there was originally.

```
268 \long\def\XINT_zapbsp_end\XINT_zapbsp_e\empty #1\xint_bye #2{#2#1}%
```

Here the initial chunk was not maximal. So we need to get a second piece all the way up to `\xint_bye`, we take this opportunity to remove the two initially added ending space tokens. We inserted an `\empty` to prevent brace removal. The `\expandafter` get rid of the `\empty`.

```
269 \xint_firstofone{\long\def\XINT_zapbsp_e #1 } \xint_bye
```

```
270 {\expandafter\XINT_zapbsp_f \expandafter{#1}}%
```

Let's not forget when we glue to reinsert the two intermediate space tokens.

```
271 \long\edef\XINT_zapbsp_f #1#2{#2\space\space #1}%
```

**35.11 \xintZapLastSpaces**

1.09f, written [2013/11/01].

```
272 \def\xintZapLastSpaces {\romannumeral0\xintzaplastspaces }%
```

Next macro is defined via an \edef for the space tokens.

```
273 \long\edef\xintzaplastspaces #1{\noexpand\XINT_zapesp_a {\space}\noexpand\empty
274                               #1\space\space\noexpand\xint_bye \xint_relax}%
```

This creates a delimited macro with two space tokens:

```
275 \xint_firstofone {\long\def\XINT_zapesp_a #1#2 } %<- second space here
276     {\expandafter\XINT_zapesp_b\expandafter{#2}{#1}}%
```

The \empty from \xintzaplastspaces is to prevent brace removal in the #2 above.  
The \expandafter chain removes it.

```
277 \long\def\XINT_zapesp_b #1#2#3\xint_relax
278     {\XINT_zapesp_end? #3\XINT_zapesp_e {#2#1}\empty #3\xint_relax }%
```

When we have reached the ending space tokens, #3 is a bunch of spaces followed by \xint\_bye. So the #1 below will be \xint\_bye. In all other cases #1 can not be \xint\_bye nor can it give birth to it via brace stripping.

```
279 \long\def\XINT_zapesp_end? #1{\xint_bye #1\XINT_zapesp_end }%
```

We are done. The #1 here has accumulated all the previous material. It started with a space token which stops the \romannumeral0. The reason for the space is the recycling of this code in \xintZapSpaces.

```
280 \long\def\XINT_zapesp_end\XINT_zapesp_e #1#2\xint_relax {#1}%
```

We haven't yet reached the end, so we need to re-inject two space tokens after what we have gotten so far. Then we loop. We might wonder why in \XINT\_zapesp\_b we scooped everything up to the end, rather than trying to test if the next thing was a bunch of spaces followed by \xint\_bye\xint\_relax. But how can we expandably examine what comes next? if we pick up something as undelimited parameter token we risk brace removal and we will never know about it so we cannot reinsert correctly; the only way is to gather a delimited macro parameter and be sure some token will be inside to forbid brace removal. I do not see (so far) any other way than scooping everything up to the end. Anyhow, 99% of the use cases will NOT have <sp><sp> inside!.

```
281 \long\edef\XINT_zapesp_e #1{\noexpand \XINT_zapesp_a {#1\space\space}}%
```

### 35.12 `\xintZapSpaces`

1.09f, written [2013/11/01].

```
282 \def\xintZapSpaces {\romannumeral0\xintzapspaces }%
```

We start like `\xintZapStartSpaces`.

```
283 \long\edef\xintzapspaces #1%
```

```
284   {\noexpand\XINT_zapsp_a \space #1\space\space\noexpand\xint_bye\xint_relax}%
```

Once the loop stripping the starting spaces is done, we plug into the `\xintZapLastSpaces` code via `\XINT_zapsp_b`. As our #1 will always have an initial space, this is why we arranged code of `\xintZapLastSpaces` to do the same.

```
285 \xint_firstofone {\long\def\XINT_zapsp_a #1 } %<- space token here
```

```
286 {%
```

```
287   \XINT_zapsp_again? #1\xint_bye\XINT_zapsp_b {#1}{}%
```

```
288 }%
```

```
289 \long\def\XINT_zapsp_again? #1{\xint_bye #1\XINT_zapsp_again }%
```

```
290 \long\edef\XINT_zapsp_again\XINT_zapsp_b #1#2{\noexpand\XINT_zapsp_a\space }%
```

### 35.13 `\xintZapSpacesB`

1.09f, written [2013/11/01].

```
291 \def\xintZapSpacesB {\romannumeral0\xintzapspacesb }%
```

```
292 \long\def\xintzapspacesb #1{\XINT_zapspb_one? #1\xint_relax\xint_relax
```

```
293   \xint_bye\xintzapspaces {#1}}%
```

```
294 \long\def\XINT_zapspb_one? #1#2%
```

```
295   {\xint_gob_til_xint_relax #1\XINT_zapspb_onlyspaces\xint_relax
```

```
296   \xint_gob_til_xint_relax #2\XINT_zapspb_bracedorone\xint_relax
```

```
297   \xint_bye {#1}}%
```

```
298 \def\XINT_zapspb_onlyspaces\xint_relax
```

```
299   \xint_gob_til_xint_relax\xint_relax\XINT_zapspb_bracedorone\xint_relax
```

```
300   \xint_bye #1\xint_bye\xintzapspaces #2{ }%
```

```
301 \long\def\XINT_zapspb_bracedorone\xint_relax
```

```
302   \xint_bye #1\xint_relax\xint_bye\xintzapspaces #2{ #1}%
```

### 35.14 `\xintCSVtoList`, `\xintCSVtoListNonStripped`

`\xintCSVtoList` transforms `a,b,...,z` into `{a}{b}...{z}`. The comma separated list may be a macro which is first expanded (protect the first item with a space if it is not to be expanded). First included in release 1.06. Here, use of `\Z` (and `\R`) perfectly safe.

[2013/11/02]: Starting with 1.09f, automatically filters items through `\xintZapSpacesB` to strip off all spaces around commas, and spaces at the start and end of the list. The original is kept as `\xintCSVtoListNonStripped`, and is faster. But ... it doesn't strip spaces.

```

303 \def\xintCSVtoList {\romannumeral0\xintcsvtolist }%
304 \long\def\xintcsvtolist #1{\expandafter\xintApply
305     \expandafter\xintzapspacesb
306     \expandafter{\romannumeral0\xintcsvtolistnonstripped{#1}}}%
307 \def\xintCSVtoListNoExpand {\romannumeral0\xintcsvtolistnoexpand }%
308 \long\def\xintcsvtolistnoexpand #1{\expandafter\xintApply
309     \expandafter\xintzapspacesb
310     \expandafter{\romannumeral0\xintcsvtolistnonstrippednoexpand{#1}}}%
311 \def\xintCSVtoListNonStripped {\romannumeral0\xintcsvtolistnonstripped }%
312 \def\xintCSVtoListNonStrippedNoExpand
313     {\romannumeral0\xintcsvtolistnonstrippednoexpand }%
314 \long\def\xintcsvtolistnonstripped #1%
315 {%
316     \expandafter\XINT_csvtol_loop_a\expandafter
317     {\expandafter}\romannumeral-‘0#1%
318         ,\xint_bye,\xint_bye,\xint_bye,\xint_bye
319         ,\xint_bye,\xint_bye,\xint_bye,\xint_bye,\Z
320 }%
321 \long\def\xintcsvtolistnonstrippednoexpand #1%
322 {%
323     \XINT_csvtol_loop_a
324     {}#1,\xint_bye,\xint_bye,\xint_bye,\xint_bye
325     ,\xint_bye,\xint_bye,\xint_bye,\xint_bye,\Z
326 }%
327 \long\def\XINT_csvtol_loop_a #1#2,#3,#4,#5,#6,#7,#8,#9,%
328 {%
329     \xint_bye #9\XINT_csvtol_finish_a\xint_bye
330     \XINT_csvtol_loop_b {#1}{#2}{#3}{#4}{#5}{#6}{#7}{#8}{#9}}%
331 }%
332 \long\def\XINT_csvtol_loop_b #1#2{\XINT_csvtol_loop_a {#1#2}}%
333 \long\def\XINT_csvtol_finish_a\xint_bye\XINT_csvtol_loop_b #1#2#3\Z
334 {%
335     \XINT_csvtol_finish_b #3\R,\R,\R,\R,\R,\R,\R,\Z #2{#1}%
336 }%
337 \def\XINT_csvtol_finish_b #1,#2,#3,#4,#5,#6,#7,#8\Z
338 {%
339     \xint_gob_til_R
340     #1\XINT_csvtol_finish_c 8%
341     #2\XINT_csvtol_finish_c 7%
342     #3\XINT_csvtol_finish_c 6%
343     #4\XINT_csvtol_finish_c 5%
344     #5\XINT_csvtol_finish_c 4%
345     #6\XINT_csvtol_finish_c 3%
346     #7\XINT_csvtol_finish_c 2%
347     \R\XINT_csvtol_finish_c 1\Z
348 }%
349 \def\XINT_csvtol_finish_c #1#2\Z
350 {%
351     \csname XINT_csvtol_finish_d\romannumeral #1\endcsname

```

```

352 }%
353 \long\def\XINT_csvtol_finish_dviii #1#2#3#4#5#6#7#8#9{ #9}%
354 \long\def\XINT_csvtol_finish_dvii #1#2#3#4#5#6#7#8#9{ #9{#1}}%
355 \long\def\XINT_csvtol_finish_dvi #1#2#3#4#5#6#7#8#9{ #9{#1}{#2}}%
356 \long\def\XINT_csvtol_finish_dv #1#2#3#4#5#6#7#8#9{ #9{#1}{#2}{#3}}%
357 \long\def\XINT_csvtol_finish_div #1#2#3#4#5#6#7#8#9{ #9{#1}{#2}{#3}{#4}}%
358 \long\def\XINT_csvtol_finish_diii #1#2#3#4#5#6#7#8#9{ #9{#1}{#2}{#3}{#4}{#5}}%
359 \long\def\XINT_csvtol_finish_dii #1#2#3#4#5#6#7#8#9%
360 { #9{#1}{#2}{#3}{#4}{#5}{#6}}%
361 \long\def\XINT_csvtol_finish_di #1#2#3#4#5#6#7#8#9%
362 { #9{#1}{#2}{#3}{#4}{#5}{#6}{#7}}%

```

### 35.15 \xintListWithSep

`\xintListWithSep {sep}{a}{b}...{z}` returns a `sep b sep ... sep z`

Included in release 1.04. The 'sep' can be `\par`'s: the macro `xintlistwithsep` etc... are all declared long. 'sep' does not have to be a single token. It is not expanded. The list may be a macro and it is expanded. 1.06 modifies the 'feature' of returning sep if the list is empty: the output is now empty in that case. (sep was not used for a one element list, but strangely it was for a zero-element list).

Use of `\Z` as delimiter was objectively an error, which I fix here in 1.09e, now the code uses `\xint_bye`.

```

363 \def\xintListWithSep {\romannumeral0\xintlistwithsep}%
364 \def\xintListWithSepNoExpand {\romannumeral0\xintlistwithsepnoexpand}%
365 \long\def\xintlistwithsep #1#2%
366 {\expandafter\XINT_lws\expandafter {\romannumeral-0#2}{#1}}%
367 \long\def\XINT_lws #1#2{\XINT_lws_start {#2}#1\xint_bye}%
368 \long\def\xintlistwithsepnoexpand #1#2{\XINT_lws_start {#1}#2\xint_bye}%
369 \long\def\XINT_lws_start #1#2%
370 {%
371 \xint_bye #2\XINT_lws_dont\xint_bye
372 \XINT_lws_loop_a {#2}{#1}%
373}%
374 \long\def\XINT_lws_dont\xint_bye\XINT_lws_loop_a #1#2{}%
375 \long\def\XINT_lws_loop_a #1#2#3%
376 {%
377 \xint_bye #3\XINT_lws_end\xint_bye
378 \XINT_lws_loop_b {#1}{#2#3}{#2}%
379}%
380 \long\def\XINT_lws_loop_b #1#2{\XINT_lws_loop_a {#1#2}}%
381 \long\def\XINT_lws_end\xint_bye\XINT_lws_loop_b #1#2#3{ #1}%

```

### 35.16 \xintNthElt

`\xintNthElt {i}{a}{b}...{z}` (or 'tokens' `abcd...z`) returns the *i*th element (one pair of braces removed). The list is first expanded. First included in release 1.06. With 1.06a, a value of *i* = 0 (or negative) makes the macro return the length.

This is different from `\xintLen` which is for numbers (checks sign) and different from `\xintLength` which does not first expand its argument. With 1.09b, only `i=0` gives the length, negative values return the `i`th element from the end. 1.09c has some slightly less quick initial preparation (if #2 is very long, not good to have it twice), I wanted to respect the `noexpand` directive in all cases, and the alternative would be to define more macros.

At some point I turned the `\W`'s into `\xint_relax`'s but forgot to modify accordingly `\XINT_nthelt_finish`. So in case the index is larger than the number of items the macro returned was an `\xint_relax` token rather than nothing. Fixed in 1.09e. I also take the opportunity of this fix to replace uses of `\Z` by `\xint_bye`. (and as a result I must do the change also in `\XINT_length_loop` and related macros).

```

382 \def\xintNthElt          {\romannumeral0\xintnthelt }%
383 \def\xintNthEltNoExpand {\romannumeral0\xintntheltnoexpand}%
384 \def\xintnthelt #1%
385 {%
386   \expandafter\XINT_nthelt_a\expandafter {\the\numexpr #1}%
387 }%
388 \def\xintntheltnoexpand #1%
389 {%
390   \expandafter\XINT_ntheltnoexpand_a\expandafter {\the\numexpr #1}%
391 }%
392 \long\def\XINT_nthelt_a #1#2%
393 {%
394   \ifnum #1<0
395     \xint_afterfi{\expandafter\XINT_nthelt_c\expandafter
396                  {\romannumeral0\xintrevwithbraces {#2}}{-#1}}%
397   \else
398     \xint_afterfi{\expandafter\XINT_nthelt_c\expandafter
399                  {\romannumeral-'0#2}{#1}}%
400   \fi
401 }%
402 \long\def\XINT_ntheltnoexpand_a #1#2%
403 {%
404   \ifnum #1<0
405     \xint_afterfi{\expandafter\XINT_nthelt_c\expandafter
406                  {\romannumeral0\xintrevwithbracesnoexpand {#2}}{-#1}}%
407   \else
408     \xint_afterfi{\expandafter\XINT_nthelt_c\expandafter
409                  {#2}{#1}}%
410   \fi
411 }%
412 \long\def\XINT_nthelt_c #1#2%
413 {%
414   \ifnum #2>\xint_c_
415     \expandafter\XINT_nthelt_loop_a
416   \else
417     \expandafter\XINT_length_loop
418   \fi {#2}#1\xint_relax\xint_relax\xint_relax\xint_relax

```

```

419      \xint_relax\xint_relax\xint_relax\xint_relax\xint_bye
420 }%
421 \def\xINT_nthelt_loop_a #1%
422 {%
423   \ifnum #1>\xint_c_viii
424     \expandafter\xINT_nthelt_loop_b
425   \else
426     \expandafter\xINT_nthelt_getit
427   \fi
428   {#1}%
429 }%
430 \long\def\xINT_nthelt_loop_b #1#2#3#4#5#6#7#8#9%
431 {%
432   \xint_gob_til_xint_relax #9\xINT_nthelt_silentend\xint_relax
433   \expandafter\xINT_nthelt_loop_a\expandafter{\the\numexpr #1-8}%
434 }%
435 \def\xINT_nthelt_silentend #1\xint_bye { }%
436 \def\xINT_nthelt_getit #1%
437 {%
438   \expandafter\expandafter\expandafter\xINT_nthelt_finish
439   \csname xint_gobble_\romannumeral\numexpr#1-1\endcsname
440 }%
441 \long\edef\xINT_nthelt_finish #1#2\xint_bye
442   {\noexpand\xint_gob_til_xint_relax #1\noexpand\expandafter\space
443     \noexpand\xint_gobble_iii\xint_relax\space #1}%

```

### 35.17 \xintApply

\xintApply {\macro}{a}{b}...{z} returns {\macro{a}}...{\macro{b}} where each instance of \macro is ff-expanded. The list is first expanded and may thus be a macro. Introduced with release 1.04.

Modified in 1.09e to not use \Z but rather \xint\_bye.

```

444 \def\xintApply      {\romannumeral0\xintapply }%
445 \def\xintApplyNoExpand {\romannumeral0\xintapplynoexpand }%
446 \long\def\xintapply #1#2%
447 {%
448   \expandafter\xINT_apply\expandafter {\romannumeral-‘0#2}%
449   {#1}%
450 }%
451 \long\def\xINT_apply #1#2{\xINT_apply_loop_a {}{#2}#1\xint_bye }%
452 \long\def\xintapplynoexpand #1#2{\xINT_apply_loop_a {}{#1}#2\xint_bye }%
453 \long\def\xINT_apply_loop_a #1#2#3%
454 {%
455   \xint_bye #3\xINT_apply_end\xint_bye
456   \expandafter
457   \xINT_apply_loop_b
458   \expandafter {\romannumeral-‘0#2{#3}}{#1}{#2}%
459 }%

```

```

460 \long\def\XINT_apply_loop_b #1#2{\XINT_apply_loop_a {#2{#1}}}%
461 \long\def\XINT_apply_end\xint_bye\expandafter\XINT_apply_loop_b
462   \expandafter #1#2#3{ #2}%

```

### 35.18 \xintApplyUnbraced

\xintApplyUnbraced {\macro}{a}{b}...{z} returns \macro{a}... \macro{z} where each instance of \macro is expanded using \romannumeral-‘0. The second argument may be a macro as it is first expanded itself (fully). No braces are added: this allows for example a non-expandable \def in \macro, without having to do \gdef. The list is first expanded. Introduced with release 1.06b. Define \macro to start with a space if it is not expandable or its execution should be delayed only when all of \macro{a}... \macro{z} is ready.

Modified in 1.09e to use \xint\_bye rather than \Z.

```

463 \def\xintApplyUnbraced {\romannumeral0\xintapplyunbraced }%
464 \def\xintApplyUnbracedNoExpand {\romannumeral0\xintapplyunbracednoexpand }%
465 \long\def\xintapplyunbraced #1#2%
466 {%
467   \expandafter\XINT_applyunbr\expandafter {\romannumeral-‘0#2}%
468   {#1}%
469 }%
470 \long\def\XINT_applyunbr #1#2{\XINT_applyunbr_loop_a {}{#2}#1\xint_bye }%
471 \long\def\xintapplyunbracednoexpand #1#2%
472   {\XINT_applyunbr_loop_a {}{#1}#2\xint_bye }%
473 \long\def\XINT_applyunbr_loop_a #1#2#3%
474 {%
475   \xint_bye #3\XINT_applyunbr_end\xint_bye
476   \expandafter\XINT_applyunbr_loop_b
477   \expandafter {\romannumeral-‘0#2{#3}}{#1}{#2}%
478 }%
479 \long\def\XINT_applyunbr_loop_b #1#2{\XINT_applyunbr_loop_a {#2#1}}%
480 \long\def\XINT_applyunbr_end\xint_bye\expandafter\XINT_applyunbr_loop_b
481   \expandafter #1#2#3{ #2}%

```

### 35.19 \xintSeq

1.09c. Without the optional argument puts stress on the input stack, should not be used to generated thousands of terms then. Here also, let’s use \xint\_bye rather than \Z as delimiter (1.09e; necessary change as #1 is used prior to being expanded, thus \Z might very well arise here as a macro).

```

482 \def\xintSeq {\romannumeral0\xintseq }%
483 \def\xintseq #1{\XINT_seq_chkopt #1\xint_bye }%
484 \def\XINT_seq_chkopt #1%
485 {%
486   \ifx [#1\expandafter\XINT_seq_opt
487     \else\expandafter\XINT_seq_noopt

```

```

488   \fi   #1%
489 }%
490 \def\XINT_seq_noopt #1\xint_bye #2%
491 {%
492   \expandafter\XINT_seq\expandafter
493     {\the\numexpr#1\expandafter}\expandafter{\the\numexpr #2}%
494 }%
495 \def\XINT_seq #1#2%
496 {%
497   \ifcase\ifnum #1=#2 0\else\ifnum #2>#1 1\else -1\fi\fi\space
498     \expandafter\xint_firstoftwo_thenstop
499   \or
500     \expandafter\XINT_seq_p
501   \else
502     \expandafter\XINT_seq_n
503   \fi
504   {#2}{#1}%
505 }%
506 \def\XINT_seq_p #1#2%
507 {%
508   \ifnum #1>#2
509     \expandafter\expandafter\expandafter\XINT_seq_p
510   \else
511     \expandafter\XINT_seq_e
512   \fi
513   \expandafter{\the\numexpr #1-\xint_c_i}{#2}{#1}%
514 }%
515 \def\XINT_seq_n #1#2%
516 {%
517   \ifnum #1<#2
518     \expandafter\expandafter\expandafter\XINT_seq_n
519   \else
520     \expandafter\XINT_seq_e
521   \fi
522   \expandafter{\the\numexpr #1+\xint_c_i}{#2}{#1}%
523 }%
524 \def\XINT_seq_e #1#2#3{ }%
525 \def\XINT_seq_opt [\xint_bye #1]#2#3%
526 {%
527   \expandafter\XINT_seqo\expandafter
528     {\the\numexpr #2\expandafter}\expandafter
529     {\the\numexpr #3\expandafter}\expandafter
530     {\the\numexpr #1}%
531 }%
532 \def\XINT_seqo #1#2%
533 {%
534   \ifcase\ifnum #1=#2 0\else\ifnum #2>#1 1\else -1\fi\fi\space
535     \expandafter\XINT_seqo_a
536   \or

```

```

537     \expandafter\XINT_seqo_pa
538   \else
539     \expandafter\XINT_seqo_na
540   \fi
541   {#1}{#2}%
542 }%
543 \def\XINT_seqo_a #1#2#3{ {#1}}%
544 \def\XINT_seqo_o #1#2#3#4{ #4}%
545 \def\XINT_seqo_pa #1#2#3%
546 {%
547   \ifcase\ifnum #3=\xint_c_ 0\else\ifnum #3>\xint_c_ 1\else -1\fi\fi\space
548     \expandafter\XINT_seqo_o
549   \or
550     \expandafter\XINT_seqo_pb
551   \else
552     \xint_afterfi{\expandafter\space\xint_gobble_iv}%
553   \fi
554   {#1}{#2}{#3}{{#1}}%
555 }%
556 \def\XINT_seqo_pb #1#2#3%
557 {%
558   \expandafter\XINT_seqo_pc\expandafter{\the\numexpr #1+#3}{#2}{#3}%
559 }%
560 \def\XINT_seqo_pc #1#2%
561 {%
562   \ifnum #1>#2
563     \expandafter\XINT_seqo_o
564   \else
565     \expandafter\XINT_seqo_pd
566   \fi
567   {#1}{#2}%
568 }%
569 \def\XINT_seqo_pd #1#2#3#4{\XINT_seqo_pb {#1}{#2}{#3}{#4{#1}}}%
570 \def\XINT_seqo_na #1#2#3%
571 {%
572   \ifcase\ifnum #3=\xint_c_ 0\else\ifnum #3>\xint_c_ 1\else -1\fi\fi\space
573     \expandafter\XINT_seqo_o
574   \or
575     \xint_afterfi{\expandafter\space\xint_gobble_iv}%
576   \else
577     \expandafter\XINT_seqo_nb
578   \fi
579   {#1}{#2}{#3}{{#1}}%
580 }%
581 \def\XINT_seqo_nb #1#2#3%
582 {%
583   \expandafter\XINT_seqo_nc\expandafter{\the\numexpr #1+#3}{#2}{#3}%
584 }%
585 \def\XINT_seqo_nc #1#2%

```

```

586 {%
587   \ifnum #1<#2
588     \expandafter\XINT_seqo_o
589   \else
590     \expandafter\XINT_seqo_nd
591   \fi
592   {#1}{#2}%
593 }%
594 \def\XINT_seqo_nd #1#2#3#4{\XINT_seqo_nb {#1}{#2}{#3}{#4{#1}}}%

```

### 35.20 \xintloop, \xintbreakloop, \xintbreakloopaddo, \xintloopskiptonext

1.09g [2013/11/22]. Made long with 1.09h.

```

595 \long\def\xintloop #1#2\repeat {#1#2\xintloop_again\fi\xint_gobble_i {#1#2}}%
596 \long\def\xintloop_again\fi\xint_gobble_i #1{\fi
597   #1\xintloop_again\fi\xint_gobble_i {#1}}%
598 \long\def\xintbreakloop #1\xintloop_again\fi\xint_gobble_i #2{%
599 \long\def\xintbreakloopaddo #1#2\xintloop_again\fi\xint_gobble_i #3{#1}%
600 \long\def\xintloopskiptonext #1\xintloop_again\fi\xint_gobble_i #2{%
601   #2\xintloop_again\fi\xint_gobble_i {#2}}%

```

### 35.21 \xintilloop, \xintilloopindex, \xintouterilloopindex, \xintbreakilloop, \xintbreakilloopaddo, \xintilloopskiptonext, \xintilloopskipandredo

1.09g [2013/11/22]. Made long with 1.09h.

```

602 \def\xintilloop [#1+#2]{%
603   \expandafter\xintilloop_a\the\numexpr #1\expandafter.\the\numexpr #2.%
604 \long\def\xintilloop_a #1.#2.#3#4\repeat{%
605   #3#4\xintilloop_again\fi\xint_gobble_iii {#1}{#2}{#3#4}}%
606 \def\xintilloop_again\fi\xint_gobble_iii #1#2{%
607   \fi\expandafter\xintilloop_again_b\the\numexpr#1+#2.#2.%
608 \long\def\xintilloop_again_b #1.#2.#3{%
609   #3\xintilloop_again\fi\xint_gobble_iii {#1}{#2}{#3}}%
610 \long\def\xintbreakilloop #1\xintilloop_again\fi\xint_gobble_iii #2#3#4{%
611 \long\def\xintbreakilloopaddo
612   #1.#2\xintilloop_again\fi\xint_gobble_iii #3#4#5{#1}%
613 \long\def\xintilloopindex #1\xintilloop_again\fi\xint_gobble_iii #2%
614   {#2#1\xintilloop_again\fi\xint_gobble_iii {#2}}%
615 \long\def\xintouterilloopindex #1\xintilloop_again
616   #2\xintilloop_again\fi\xint_gobble_iii #3%
617   {#3#1\xintilloop_again #2\xintilloop_again\fi\xint_gobble_iii {#3}}%
618 \long\def\xintilloopskiptonext #1\xintilloop_again\fi\xint_gobble_iii #2#3{%
619   \expandafter\xintilloop_again_b \the\numexpr#2+#3.#3.%
620 \long\def\xintilloopskipandredo #1\xintilloop_again\fi\xint_gobble_iii #2#3#4{%
621   #4\xintilloop_again\fi\xint_gobble_iii {#2}{#3}{#4}}%

```

**35.22 \XINT\_xflet**

1.09e [2013/10/29]: we expand fully unbraced tokens and swallow arising space tokens until the dust settles. For treating cases {<blank>\x<blank>y...}, with guaranteed expansion of the \x (which may itself give space tokens), a simpler approach is possible with doubled \romannumeral-‘0, this is what I first did, but it had the feature that <sptoken><sptoken>\x would not expand the \x. At any rate, <sptoken>’s before the list terminator z were all correctly moved out of the way, hence the stuff was robust for use in (the then current versions of) \xintApplyInline and \xintFor. Although \*two\* space tokens would need devilishly prepared input, nevertheless I decided to also survive that, so here the method is a bit more complicated. But it simplifies things on the caller side.

```

622 \def\XINT_xflet #1%
623 {%
624   \def\XINT_xflet_macro {#1}\XINT_xflet_zapsp
625 }%
626 \def\XINT_xflet_zapsp
627 {%
628   \expandafter\futurelet\expandafter\XINT_token
629   \expandafter\XINT_xflet_sp?\romannumeral-‘0%
630 }%
631 \def\XINT_xflet_sp?
632 {%
633   \ifx\XINT_token\XINT_sptoken
634     \expandafter\XINT_xflet_zapsp
635   \else\expandafter\XINT_xflet_zapspB
636   \fi
637 }%
638 \def\XINT_xflet_zapspB
639 {%
640   \expandafter\futurelet\expandafter\XINT_tokenB
641   \expandafter\XINT_xflet_spB?\romannumeral-‘0%
642 }%
643 \def\XINT_xflet_spB?
644 {%
645   \ifx\XINT_tokenB\XINT_sptoken
646     \expandafter\XINT_xflet_zapspB
647   \else\expandafter\XINT_xflet_eq?
648   \fi
649 }%
650 \def\XINT_xflet_eq?
651 {%
652   \ifx\XINT_token\XINT_tokenB
653     \expandafter\XINT_xflet_macro
654   \else\expandafter\XINT_xflet_zapsp
655   \fi
656 }%

```

**35.23 \xintApplyInline**

1.09a: `\xintApplyInline\macro{a}{b}...{z}` has the same effect as executing `\macro{a}` and then applying again `\xintApplyInline` to the shortened list `{b}...{z}` until nothing is left. This is a non-expandable command which will result in quicker code than using `\xintApplyUnbraced`. It expands (fully) its second (list) argument first, which may thus be encapsulated in a macro.

Release 1.09c has a new `\xintApplyInline`: the new version, while not expandable, is designed to survive when the applied macro closes a group, as is the case in `alignemnts` when it contains a `&` or `\`. It uses catcode 3 `Z` as list terminator. Don't use it among the list items.

1.09d: the bug which was discovered in `\xintFor*` regarding space tokens at the very end of the item list also was in `\xintApplyInline`. The new version will expand unbraced item elements and this is in fact convenient to simulate insertion of lists in others.

1.09e: the applied macro is allowed to be long, with items (or the first fixed arguments of the macro, passed together with it as `#1` to `\xintApplyInline`) containing explicit `\par`'s. (1.09g: some missing `\long`'s added)

1.09f: terminator used to be `z`, now `Z` (still catcode 3).

```

657 \catcode'Z 3
658 \long\def\xintApplyInline #1#2%
659 {%
660   \long\expandafter\def\expandafter\XINT_inline_macro
661   \expandafter ##\expandafter 1\expandafter {#1{##1}}%
662   \XINT_xflet\XINT_inline_b #2Z% this Z has catcode 3
663 }%
664 \def\XINT_inline_b
665 {%
666   \ifx\XINT_token Z\expandafter\xint_gobble_i
667   \else\expandafter\XINT_inline_d\fi
668 }%
669 \long\def\XINT_inline_d #1%
670 {%
671   \long\def\XINT_item{#1}\XINT_xflet\XINT_inline_e
672 }%
673 \def\XINT_inline_e
674 {%
675   \ifx\XINT_token Z\expandafter\XINT_inline_w
676   \else\expandafter\XINT_inline_f\fi
677 }%
678 \def\XINT_inline_f
679 {%
680   \expandafter\XINT_inline_g\expandafter{\XINT_inline_macro {##1}}%
681 }%
682 \long\def\XINT_inline_g #1%
683 {%
684   \expandafter\XINT_inline_macro\XINT_item
685   \long\def\XINT_inline_macro ##1{#1}\XINT_inline_d

```

```

686 }%
687 \def\XINT_inline_w #1%
688 {%
689   \expandafter\XINT_inline_macro\XINT_item
690 }%

```

### 35.24 `\xintFor`, `\xintFor*`, `\xintBreakFor`, `\xintBreakForAndDo`

1.09c [2013/10/09]: a new kind of loop which uses macro parameters #1, #2, #3, #4 rather than macros; while not expandable it survives executing code closing groups, like what happens in an alignment with the & character. When inserted in a macro for later use, the # character must be doubled.

The non-star variant works on a csv list, which it expands once, the star variant works on a token list, expanded fully.

1.09d: [2013/10/22] `\xintFor*` crashed when a space token was at the very end of the list. It is crucial in this code to not let the ending Z be picked up as a macro parameter without knowing in advance that it is its turn. So, we conscientiously clean out of the way space tokens, but also we ff-expand with `\romannumeral-‘0` (unbraced) items, a process which may create new space tokens, so it is iterated. As unbraced items are expanded, it is easy to simulate insertion of a list in another. Unbraced items consecutive to an even (non-zero) number of space tokens will not get expanded.

1.09e: [2013/10/29] does this better, no difference between an even or odd number of explicit consecutive space tokens. Normal situations anyhow only create at most one space token, but well. There was a feature in `\xintFor` (not `\xintFor*`) from 1.09c that it treated an empty list as a list with one, empty, item. This feature is kept in 1.09e, knowingly... Also, macros are made long, hence the iterated text may contain `\par` and also the looped over items. I thought about providing some macro expanding to the loop count, but as the `\xintFor` is not expandable anyhow, there is no loss of generality if the iterated commands do themselves the bookkeeping using a count or a LaTeX counter, and deal with nesting or other problems. I can't do *\*everything\**!

1.09e adds `\XINT_forever` with `\xintintegers`, `\xintdimensions`, `\xinrationals` and `\xintBreakFor`, `\xintBreakForAndDo`, `\xintifForFirst`, `\xintifForLast`. On this occasion `\xint_firstoftwo` and `\xint_secondoftwo` are made long.

1.09f: rewrites large parts of `\xintFor` code in order to filter the comma separated list via `\xintCSVtoList` which gets rid of spaces. Compatibility with `\XINT_forever`, the necessity to prevent unwanted brace stripping, and shared code with `\xintFor*`, make this all a delicate balancing act. The #1 in `\XINT_for_forever?` has an initial space token which serves two purposes: preventing brace stripping, and stopping the expansion made by `\xintcsvtolist`. If the `\XINT_forever` branch is taken, the added space will not be a problem there.

1.09f rewrites (2013/11/03) the code which now allows all macro parameters from #1 to #9 in `\xintFor`, `\xintFor*`, and `\XINT_forever`.

The 1.09f `\xintFor` and `\xintFor*` modified the value of `\count 255` which was silly, 1.09g used `\XINT_count`, but requiring a `\count` only for that was also silly, 1.09h just uses `\numexpr` (all of that was only to get rid simply of a possibly space in #2...).

### 35 Package *xinttools* implementation

```

691 \def\XINT_tmpa #1#2{\ifnum #2<#1 \xint_afterfi {{#####2}}\fi}%
692 \def\XINT_tmpb #1#2{\ifnum #1<#2 \xint_afterfi {{#####2}}\fi}%
693 \def\XINT_tmpc #1%
694 {%
695   \expandafter\edef \csname XINT_for_left#1\endcsname
696     {\xintApplyUnbraced {\XINT_tmpa #1}{123456789}}%
697   \expandafter\edef \csname XINT_for_right#1\endcsname
698     {\xintApplyUnbraced {\XINT_tmpb #1}{123456789}}%
699 }%
700 \xintApplyInline \XINT_tmpc {123456789}%
701 \long\def\xintBreakFor #1Z{%
702 \long\def\xintBreakForAndDo #1#2Z{#1}%
703 \def\xintFor {\let\xintifForFirst\xint_firstoftwo
704   \futurelet\XINT_token\XINT_for_ifstar}%
705 \def\XINT_for_ifstar {\ifx\XINT_token*\expandafter\XINT_forx
706   \else\expandafter\XINT_for \fi}%
707 \catcode'U 3 % with numexpr
708 \catcode'V 3 % with xintfrac.sty (xint.sty not enough)
709 \catcode'D 3 % with dimexpr
710 % \def\XINT_flet #1%
711 % {%
712 %   \def\XINT_flet_macro {#1}\XINT_flet_zapsp
713 % }%
714 \def\XINT_flet_zapsp
715 {%
716   \futurelet\XINT_token\XINT_flet_sp?
717 }%
718 \def\XINT_flet_sp?
719 {%
720   \ifx\XINT_token\XINT_sptoken
721     \xint_afterfi{\expandafter\XINT_flet_zapsp\romannumeral0}%
722   \else\expandafter\XINT_flet_macro
723   \fi
724 }%
725 \long\def\XINT_for #1#2in#3#4#5%
726 {%
727   \expandafter\XINT_toks\expandafter
728     {\expandafter\XINT_for_d\the\numexpr #2\relax {#5}}%
729   \def\XINT_flet_macro {\expandafter\XINT_for_forever?\space}%
730   \expandafter\XINT_flet_zapsp #3Z%
731 }%
732 \def\XINT_for_forever? #1Z%
733 {%
734   \ifx\XINT_token U\XINT_to_forever\fi
735   \ifx\XINT_token V\XINT_to_forever\fi
736   \ifx\XINT_token D\XINT_to_forever\fi
737   \expandafter\the\expandafter\XINT_toks\romannumeral0\xintcsvtolist {#1}Z%
738 }%
739 \def\XINT_to_forever\fi #1\xintcsvtolist #2{\fi \XINT_forever #2}%

```

### 35 Package *xinttools* implementation

```

740 \long\def\XINT_forx *#1#2in#3#4#5%
741 {%
742   \expandafter\XINT_toks\expandafter
743     {\expandafter\XINT_forx_d\the\numexpr #2\relax {#5}}}%
744   \XINT_xflet\XINT_forx_forever? #3Z%
745 }%
746 \def\XINT_forx_forever?
747 {%
748   \ifx\XINT_token U\XINT_to_forxever\fi
749   \ifx\XINT_token V\XINT_to_forxever\fi
750   \ifx\XINT_token D\XINT_to_forxever\fi
751   \XINT_forx_empty?
752 }%
753 \def\XINT_to_forxever\fi #1\XINT_forx_empty? {\fi \XINT_forever }%
754 \catcode'U 11
755 \catcode'D 11
756 \catcode'V 11
757 \def\XINT_forx_empty?
758 {%
759   \ifx\XINT_token Z\expandafter\xintBreakFor\fi
760   \the\XINT_toks
761 }%
762 \long\def\XINT_for_d #1#2#3%
763 {%
764   \long\def\XINT_y ##1##2##3##4##5##6##7##8##9{#2}%
765   \XINT_toks {{#3}}%
766   \long\edef\XINT_x {\noexpand\XINT_y \csname XINT_for_left#1\endcsname
767     \the\XINT_toks \csname XINT_for_right#1\endcsname }%
768   \XINT_toks {\XINT_x\let\xintifForFirst\xint_secondoftwo\XINT_for_d #1{#2}}%
769   \futurelet\XINT_token\XINT_for_last?
770 }%
771 \long\def\XINT_forx_d #1#2#3%
772 {%
773   \long\def\XINT_y ##1##2##3##4##5##6##7##8##9{#2}%
774   \XINT_toks {{#3}}%
775   \long\edef\XINT_x {\noexpand\XINT_y \csname XINT_for_left#1\endcsname
776     \the\XINT_toks \csname XINT_for_right#1\endcsname }%
777   \XINT_toks {\XINT_x\let\xintifForFirst\xint_secondoftwo\XINT_forx_d #1{#2}}%
778   \XINT_xflet\XINT_for_last?
779 }%
780 \def\XINT_for_last?
781 {%
782   \let\xintifForLast\xint_secondoftwo
783   \ifx\XINT_token Z\let\xintifForLast\xint_firstoftwo
784     \xint_afterfi{\xintBreakForAndDo\XINT_x}\fi
785   \the\XINT_toks
786 }%

```

**35.25 \XINT\_forever, \xintintegers, \xintdimensions, \xintrationals**

New with 1.09e. But this used inadvertently \xintiadd/\xintimul which have the unnecessary \xintnum overhead. Changed in 1.09f to use \xintiiadd/\xintiimul which do not have this overhead. Also 1.09f has \xintZapSpacesB which helps getting rid of spaces for the \xintrationals case (the other cases end up inside a \numexpr, or \dimexpr, so not necessary).

```

787 \catcode'U 3
788 \catcode'D 3
789 \catcode'V 3
790 \let\xintegers      U%
791 \let\xintintegers   U%
792 \let\xintdimensions D%
793 \let\xintrationals  V%
794 \def\XINT_forever #1%
795 {%
796   \expandafter\XINT_forever_a
797   \csname XINT_?expr_!ifx#1UU\else!ifx#1DD\else V\fi\fi a\expandafter\endcsname
798   \csname XINT_?expr_!ifx#1UU\else!ifx#1DD\else V\fi\fi i\expandafter\endcsname
799   \csname XINT_?expr_!ifx#1UU\else!ifx#1DD\else V\fi\fi \endcsname
800}%
801 \catcode'U 11
802 \catcode'D 11
803 \catcode'V 11
804 \def\XINT_?expr_Ua #1#2%
805   {\expandafter{\expandafter\numexpr\the\numexpr #1\expandafter\relax
806                                     \expandafter\relax\expandafter}%
807   \expandafter{\the\numexpr #2}}%
808 \def\XINT_?expr_Da #1#2%
809   {\expandafter{\expandafter\dimexpr\number\dimexpr #1\expandafter\relax
810                                     \expandafter s\expandafter p\expandafter\relax\expandafter}%
811   \expandafter{\number\dimexpr #2}}%
812 \catcode'Z 11
813 \def\XINT_?expr_Va #1#2%
814 {%
815   \expandafter\XINT_?expr_Vb\expandafter
816   {\romannumeral-'0\xintra with zeros{\xintZapSpacesB{#2}}}%
817   {\romannumeral-'0\xintra with zeros{\xintZapSpacesB{#1}}}%
818}%
819 \catcode'Z 3
820 \def\XINT_?expr_Vb #1#2{\expandafter\XINT_?expr_Vc #2.#1}%
821 \def\XINT_?expr_Vc #1/#2.#3/#4.%
822 {%
823   \xintifEq {#2}{#4}%
824     {\XINT_?expr_Vf {#3}{#1}{#2}}%
825     {\expandafter\XINT_?expr_Vd\expandafter
826       {\romannumeral0\xintiimul {#2}{#4}}%
827       {\romannumeral0\xintiimul {#1}{#4}}%

```

### 35 Package *xinttools* implementation

```

828     {\romannumeral0\xintiimul {#2}{#3}}%
829     }%
830 }%
831 \def\xINT_?expr_Vd #1#2#3{\expandafter\xINT_?expr_Ve\expandafter {#2}{#3}{#1}}%
832 \def\xINT_?expr_Ve #1#2{\expandafter\xINT_?expr_Vf\expandafter {#2}{#1}}%
833 \def\xINT_?expr_Vf #1#2#3{{#2/#3}{{0}{#1}{#2}{#3}}}%
834 \def\xINT_?expr_Ui {{\numexpr 1\relax}{1}}%
835 \def\xINT_?expr_Di {{\dimexpr 0pt\relax}{65536}}%
836 \def\xINT_?expr_Vi {{1/1}{0111}}%
837 \def\xINT_?expr_U #1#2%
838     {\expandafter{\expandafter\numexpr\the\numexpr #1+#2\relax\relax}{#2}}%
839 \def\xINT_?expr_D #1#2%
840     {\expandafter{\expandafter\dimexpr\the\numexpr #1+#2\relax sp\relax}{#2}}%
841 \def\xINT_?expr_V #1#2{\xINT_?expr_Vx #2}%
842 \def\xINT_?expr_Vx #1#2%
843 {%
844     \expandafter\xINT_?expr_Vy\expandafter
845     {\romannumeral0\xintiiadd {#1}{#2}}{#2}%
846 }%
847 \def\xINT_?expr_Vy #1#2#3#4%
848 {%
849     \expandafter{\romannumeral0\xintiiadd {#3}{#1}/#4}{{#1}{#2}{#3}{#4}}%
850 }%
851 \def\xINT_forever_a #1#2#3#4%
852 {%
853     \ifx #4[\expandafter\xINT_forever_opt_a
854     \else\expandafter\xINT_forever_b
855     \fi #1#2#3#4%
856 }%
857 \def\xINT_forever_b #1#2#3Z{\expandafter\xINT_forever_c\the\xINT_toks #2#3}%
858 \long\def\xINT_forever_c #1#2#3#4#5%
859     {\expandafter\xINT_forever_d\expandafter #2#4#5{#3}Z}%
860 \def\xINT_forever_opt_a #1#2#3[#4+#5]#6Z%
861 {%
862     \expandafter\expandafter\expandafter
863     \xINT_forever_opt_c\expandafter\the\expandafter\xINT_toks
864     \romannumeral-‘0#1{#4}{#5}#3%
865 }%
866 \long\def\xINT_forever_opt_c #1#2#3#4#5#6{\xINT_forever_d #2{#4}{#5}#6{#3}Z}%
867 \long\def\xINT_forever_d #1#2#3#4#5%
868 {%
869     \long\def\xINT_y ##1##2##3##4##5##6##7##8##9{#5}%
870     \xINT_toks {{#2}}%
871     \long\edef\xINT_x {\noexpand\xINT_y \csname XINT_for_left#1\endcsname
872         \the\xINT_toks \csname XINT_for_right#1\endcsname }%
873     \xINT_x
874     \let\xintifForFirst\xint_secondoftwo
875     \expandafter\xINT_forever_d\expandafter #1\romannumeral-‘0#4{#2}{#3}#4{#5}%
876 }%

```

**35.26 \xintForpair, \xintForthree, \xintForfour**

1.09c: I don't know yet if {a}{b} is better for the user or worse than (a,b). I prefer the former. I am not very motivated to deal with spaces in the (a,b) approach which is the one (currently) followed here.

[2013/11/02] 1.09f: I may not have been very motivated in 1.09c, but since then I developed the \xintZapSpaces/\xintZapSpacesB tools (much to my satisfaction). Based on this, and better parameter texts, \xintForpair and its cousins now handle spaces very satisfactorily (this relies partly on the new \xintCSVtoList which makes use of \xintZapSpacesB). Does not share code with \xintFor anymore.

[2013/11/03] 1.09f: \xintForpair extended to accept #1#2, #2#3 etc... up to #8#9, \xintForthree, #1#2#3 up to #7#8#9, \xintForfour id.

```

877 \catcode'j 3
878 \long\def\xintForpair #1#2#3in#4#5#6%
879 {%
880   \let\xintifForFirst\xint_firstoftwo
881   \XINT_toks {\XINT_forpair_d #2{#6}}%
882   \expandafter\the\expandafter\XINT_toks #4jZ%
883}%
884 \long\def\XINT_forpair_d #1#2#3(#4)#5%
885 {%
886   \long\def\XINT_y ##1##2##3##4##5##6##7##8##9{#2}%
887   \XINT_toks \expandafter{\romannumeral0\xintcsvtolist{ #4}}%
888   \long\edef\XINT_x {\noexpand\XINT_y \csname XINT_for_left#1\endcsname
889     \the\XINT_toks \csname XINT_for_right\the\numexpr#1+1\endcsname}%
890   \let\xintifForLast\xint_secondoftwo
891   \ifx #5j\let\xintifForLast\xint_firstoftwo\expandafter\xintBreakForAndDo\fi
892   \XINT_x\let\xintifForFirst\xint_secondoftwo\XINT_forpair_d #1{#2}%
893}%
894 \long\def\xintForthree #1#2#3in#4#5#6%
895 {%
896   \let\xintifForFirst\xint_firstoftwo
897   \XINT_toks {\XINT_forthree_d #2{#6}}%
898   \expandafter\the\expandafter\XINT_toks #4jZ%
899}%
900 \long\def\XINT_forthree_d #1#2#3(#4)#5%
901 {%
902   \long\def\XINT_y ##1##2##3##4##5##6##7##8##9{#2}%
903   \XINT_toks \expandafter{\romannumeral0\xintcsvtolist{ #4}}%
904   \long\edef\XINT_x {\noexpand\XINT_y \csname XINT_for_left#1\endcsname
905     \the\XINT_toks \csname XINT_for_right\the\numexpr#1+2\endcsname}%
906   \let\xintifForLast\xint_secondoftwo
907   \ifx #5j\let\xintifForLast\xint_firstoftwo\expandafter\xintBreakForAndDo\fi
908   \XINT_x\let\xintifForFirst\xint_secondoftwo\XINT_forthree_d #1{#2}%
909}%
910 \long\def\xintForfour #1#2#3in#4#5#6%
911 {%
912   \let\xintifForFirst\xint_firstoftwo

```

```

913 \XINT_toks {\XINT_forfour_d #2{#6}}%
914 \expandafter\the\expandafter\XINT_toks #4jZ%
915 }%
916 \long\def\XINT_forfour_d #1#2#3(#4)#5%
917 {%
918 \long\def\XINT_y ##1##2##3##4##5##6##7##8##9{#2}%
919 \XINT_toks \expandafter{\romannumeral0\xintcsvtolist{ #4}}%
920 \long\edef\XINT_x {\noexpand\XINT_y \csname XINT_for_left#1\endcsname
921 \the\XINT_toks \csname XINT_for_right\the\numexpr#1+3\endcsname}%
922 \let\xintifForLast\xint_secondoftwo
923 \ifx #5j\let\xintifForLast\xint_firstoftwo\expandafter\xintBreakForAndDo\fi
924 \XINT_x\let\xintifForFirst\xint_secondoftwo\XINT_forfour_d #1{#2}%
925 }%
926 \catcode'Z 11
927 \catcode'j 11

```

### 35.27 \xintAssign, \xintAssignArray, \xintDigitsOf

\xintAssign {a}{b}..{z}\to A\B...Z,  
\xintAssignArray {a}{b}..{z}\to U

version 1.01 corrects an oversight in 1.0 related to the value of \escapechar at the time of using \xintAssignArray or \xintRelaxArray These macros are non-expandable.

In version 1.05a I suddenly see some incongruous \expandafter's in (what is called now) \XINT\_assignarray\_end\_c, which I remove.

Release 1.06 modifies the macros created by \xintAssignArray to feed their argument to a \numexpr. Release 1.06a detects an incredible typo in 1.01, (bad copy-paste from \xintRelaxArray) which caused \xintAssignArray to use #1 rather than the #2 as in the correct earlier 1.0 version!!! This went through undetected because \xint\_arrayname, although weird, was still usable: the probability to overwrite something was almost zero. The bug got finally revealed doing \xintAssignArray {}{}{} \to \Stuff.

With release 1.06b an empty argument (or expanding to empty) to \xintAssignArray is ok.

1.09h simplifies the coding of \xintAssignArray (no more \_end\_a, \_end\_b, etc...), and no use of a \count register anymore, and uses \xintloop in \xintRelaxArray. Furthermore, macros are made long.

1.09i allows an optional parameter \xintAssign [oo] for example, then \oodef rather than \edef is used. Idem for \xintAssignArray. However in the latter case, the global variant is not available, one should use \globaldefs for that.

1.09j: I decide that the default behavior of \xintAssign should be to use \def, not \edef when assigning to a cs an item of the list. This is a breaking change but I don't think anybody on earth is using xint anyhow. Also use of the optional parameter was broken if it was [], [g], [e], [x] as the corresponding \XINT\_... macros had not been defined (in the initial version I did not have the XINT\_ prefix; then I added it in case \oodef was pre-existing and thus was not redefined by the package which instead had \XINT\_oodef, now \xintoodef.)

```

928 \def\xintAssign{\def\XINT_flet_macro {\XINT_assign_fork}\XINT_flet_zapsp }%

```

```

929 \def\XINT_assign_fork
930 {%
931   \let\XINT_assign_def\def
932   \ifx\XINT_token[\expandafter\XINT_assign_opt
933     \else\expandafter\XINT_assign_a
934   \fi
935 }%
936 \def\XINT_assign_opt [#1]%
937 {%
938   \ifcsname #1def\endcsname
939     \expandafter\let\expandafter\XINT_assign_def \csname #1def\endcsname
940   \else
941     \expandafter\let\expandafter\XINT_assign_def \csname xint#1def\endcsname
942   \fi
943   \XINT_assign_a
944 }%
945 \long\def\XINT_assign_a #1\to
946 {%
947   \expandafter\XINT_assign_b\romannumeral-'0#1{}\to
948 }%
949 \long\def\XINT_assign_b #1% attention to the # at the beginning of next line
950 #{%
951   \def\xint_temp {#1}%
952   \ifx\empty\xint_temp
953     \expandafter\XINT_assign_c
954   \else
955     \expandafter\XINT_assign_d
956   \fi
957 }%
958 \long\def\XINT_assign_c #1#2\to #3%
959 {%
960   \XINT_assign_def #3{#1}%
961   \def\xint_temp {#2}%
962   \unless\ifx\empty\xint_temp\xint_afterfi{\XINT_assign_b #2\to }\fi
963 }%
964 \def\XINT_assign_d #1\to #2% normally #1 is {} here.
965 {%
966   \expandafter\XINT_assign_def\expandafter #2\expandafter{\xint_temp}%
967 }%
968 \def\xintRelaxArray #1%
969 {%
970   \edef\XINT_restoreescapechar {\escapechar\the\escapechar\relax}%
971   \escapechar -1
972   \expandafter\def\expandafter\xint_arrayname\expandafter {\string #1}%
973   \XINT_restoreescapechar
974   \xintilooop [\csname\xint_arrayname 0\endcsname+-1]
975   \global
976   \expandafter\let\csname\xint_arrayname\xintilooopindex\endcsname\relax
977   \ifnum \xintilooopindex > \xint_c_

```

### 35 Package *xinttools* implementation

```

978 \repeat
979 \global\expandafter\let\csname\xint_arrayname 00\endcsname\relax
980 \global\let #1\relax
981 }%
982 \def\xintAssignArray{\def\XINT_flet_macro {\XINT_assignarray_fork}%
983 \XINT_flet_zapsp }%
984 \def\XINT_assignarray_fork
985 {%
986 \let\XINT_assignarray_def\def
987 \ifx\XINT_token[\expandafter\XINT_assignarray_opt
988 \else\expandafter\XINT_assignarray
989 \fi
990 }%
991 \def\XINT_assignarray_opt [#1]%
992 {%
993 \ifcsname #1def\endcsname
994 \expandafter\let\expandafter\XINT_assignarray_def \csname #1def\endcsname
995 \else
996 \expandafter\let\expandafter\XINT_assignarray_def
997 \csname xint#1def\endcsname
998 \fi
999 \XINT_assignarray
1000 }%
1001 \long\def\XINT_assignarray #1\to #2%
1002 {%
1003 \edef\XINT_restoreescapechar {\escapechar\the\escapechar\relax }%
1004 \escapechar -1
1005 \expandafter\def\expandafter\xint_arrayname\expandafter {\string #2}%
1006 \XINT_restoreescapechar
1007 \def\xint_itemcount {0}%
1008 \expandafter\XINT_assignarray_loop \romannumeral-'0#1\xint_relax
1009 \csname\xint_arrayname 00\expandafter\endcsname
1010 \csname\xint_arrayname 0\expandafter\endcsname
1011 \expandafter {\xint_arrayname}#2%
1012 }%
1013 \long\def\XINT_assignarray_loop #1%
1014 {%
1015 \def\xint_temp {#1}%
1016 \ifx\xint_brelax\xint_temp
1017 \expandafter\def\csname\xint_arrayname 0\expandafter\endcsname
1018 \expandafter{\the\numexpr\xint_itemcount}%
1019 \expandafter\expandafter\expandafter\XINT_assignarray_end
1020 \else
1021 \expandafter\def\expandafter\xint_itemcount\expandafter
1022 {\the\numexpr\xint_itemcount+\xint_c_i}%
1023 \expandafter\XINT_assignarray_def
1024 \csname\xint_arrayname\xint_itemcount\expandafter\endcsname
1025 \expandafter{\xint_temp }%
1026 \expandafter\XINT_assignarray_loop

```

```

1027 \fi
1028 }%
1029 \def\XINT_assignarray_end #1#2#3#4%
1030 {%
1031 \def #4##1%
1032 {%
1033 \romannumeral0\expandafter #1\expandafter{\the\numexpr ##1}%
1034 }%
1035 \def #1##1%
1036 {%
1037 \ifnum ##1<\xint_c_
1038 \xint_afterfi {\xintError:ArrayIndexIsNegative\space }%
1039 \else
1040 \xint_afterfi {%
1041 \ifnum ##1>#2
1042 \xint_afterfi {\xintError:ArrayIndexBeyondLimit\space }%
1043 \else\xint_afterfi
1044 {\expandafter\expandafter\expandafter\space\csname #3##1\endcsname}%
1045 \fi}%
1046 \fi
1047 }%
1048 }%
1049 \let\xintDigitsOf\xintAssignArray
1050 \let\XINT_tmpa\relax \let\XINT_tmpp\relax \let\XINT_tmppc\relax
1051 \XINT_restorecatcodes_endinput%

```

## 36 Package **xint** implementation

With release 1.09a all macros doing arithmetic operations and a few more apply systematically `\xint-` to their arguments; this adds a little overhead but this is more convenient for using count registers even with infix notation; also this is what `xintfrac.sty` did all along. Simplifies the discussion in the documentation too.

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.24 \xintifOdd.....	186	.51 \xintMON, \xintMMON.....	245
.25 \xintOpp.....	186	.52 \xintOdd.....	246
.26 \xintAbs.....	186	.53 \xintDSL.....	247
.27 \xintAdd.....	195	.54 \xintDSR.....	247
.28 \xintSub.....	196	.55 \xintDSH, \xintDSHr.....	248
.29 \xintCmp.....	202	.56 \xintDSx.....	249
.30 \xintEq, \xintGt, \xintLt.....	205	.57 \xintDecSplit, \xintDecSplitL,	
.31 \xintIsZero, \xintIsNotZero.....	205	\xintDecSplitR.....	252
.32 \xintIsTrue, \xintNot, \xintIsFalse	205	.58 \xintDouble.....	255
.33 \xintAND, \xintOR, \xintXOR.....	205	.59 \xintHalf.....	256
.34 \xintANDof.....	206	.60 \xintDec.....	257
.35 \xintORof.....	206	.61 \xintInc.....	258
.36 \xintXORof.....	206	.62 \xintiSqrt, \xintiSquareRoot	259
.37 \xintGeq.....	207	.63 \xintIsTrue:csv.....	263
.38 \xintMax.....	209	.64 \xintANDof:csv.....	263
.39 \xintMaxof.....	210	.65 \xintORof:csv.....	264
.40 \xintMin.....	210	.66 \xintXORof:csv.....	264
.41 \xintMinof.....	211	.67 \xintiMaxof:csv.....	264
.42 \xintSum.....	212	.68 \xintiMinof:csv.....	264
.43 \xintMul.....	213	.69 \xintiiSum:csv.....	265
.44 \xintSqr.....	222	.70 \xintiiPrd:csv.....	265
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### 36.1 Catcodes, $\varepsilon$ -TeX and reload detection

The code for reload detection is copied from HEIKO OBERDIEK's packages, and adapted here to check for previous loading of the master *xint* package.

The method for catcodes is slightly different, but still directly inspired by these packages.

```

1 \begingroup\catcode61\catcode48\catcode32=10\relax%
2 \catcode13=5 % ^^M
3 \endlinechar=13 %
4 \catcode123=1 % {
5 \catcode125=2 % }
6 \catcode64=11 % @
7 \catcode35=6 % #
8 \catcode44=12 % ,
9 \catcode45=12 % -
10 \catcode46=12 % .
11 \catcode58=12 % :
12 \def\space { }%
```

```

13 \let\z\endgroup
14 \expandafter\let\expandafter\x\csname ver@xint.sty\endcsname
15 \expandafter\let\expandafter\w\csname ver@xinttools.sty\endcsname
16 \expandafter
17 \ifx\csname PackageInfo\endcsname\relax
18 \def\y#1#2{\immediate\write-1{Package #1 Info: #2.}}%
19 \else
20 \def\y#1#2{\PackageInfo{#1}{#2}}%
21 \fi
22 \expandafter
23 \ifx\csname numexpr\endcsname\relax
24 \y{xint}{\numexpr not available, aborting input}%
25 \aftergroup\endinput
26 \else
27 \ifx\x\relax % plain-TeX, first loading of xint.sty
28 \ifx\w\relax % but xinttools.sty not yet loaded.
29 \y{xint}{now issuing \string\input\space xinttools.sty}%
30 \def\z{\endgroup\input xinttools.sty\relax}%
31 \fi
32 \else
33 \def\empty {}%
34 \ifx\x\empty % LaTeX, first loading,
35 % variable is initialized, but \ProvidesPackage not yet seen
36 \ifx\w\relax % xinttools.sty not yet loaded.
37 \y{xint}{now issuing \string\RequirePackage{xinttools}}%
38 \def\z{\endgroup\RequirePackage{xinttools}}%
39 \fi
40 \else
41 \y{xint}{I was already loaded, aborting input}%
42 \aftergroup\endinput
43 \fi
44 \fi
45 \fi
46 \z%

```

## 36.2 Confirmation of *xinttools* loading

```

47 \begingroup\catcode61\catcode48\catcode32=10\relax%
48 \catcode13=5 % ^^M
49 \endlinechar=13 %
50 \catcode123=1 % {
51 \catcode125=2 % }
52 \catcode64=11 % @
53 \catcode35=6 % #
54 \catcode44=12 % ,
55 \catcode45=12 % -
56 \catcode46=12 % .
57 \catcode58=12 % :
58 \ifdefined\PackageInfo

```

```

59     \def\y#1#2{\PackageInfo{#1}{#2}}%
60     \else
61     \def\y#1#2{\immediate\write-1{Package #1 Info: #2.}}%
62 \fi
63 \def\empty {}%
64 \expandafter\let\expandafter\w\csname ver@xinttools.sty\endcsname
65 \ifx\w\relax % Plain TeX, user gave a file name at the prompt
66     \y{xint}{Loading of package xinttools failed, aborting input}%
67     \aftergroup\endinput
68 \fi
69 \ifx\w\empty % LaTeX, user gave a file name at the prompt
70     \y{xint}{Loading of package xinttools failed, aborting input}%
71     \aftergroup\endinput
72 \fi
73 \endgroup%

```

### 36.3 Catcodes

```

74 \XINTsetupcatcodes%

```

### 36.4 Package identification

```

75 \XINT_providespackage
76 \ProvidesPackage{xint}%
77 [2014/01/09 v1.09j Expandable operations on long numbers (jfb)]%

```

### 36.5 Token management, constants

```

78 \long\def\xint_firstofthree #1#2#3{#1}%
79 \long\def\xint_secondofthree #1#2#3{#2}%
80 \long\def\xint_thirdofthree #1#2#3{#3}%
81 \long\def\xint_firstofthree_thenstop #1#2#3{ #1}% 1.09i
82 \long\def\xint_secondofthree_thenstop #1#2#3{ #2}%
83 \long\def\xint_thirdofthree_thenstop #1#2#3{ #3}%
84 \def\xint_gob_til_zero #10{}%
85 \def\xint_gob_til_zeros_iii #1000{}%
86 \def\xint_gob_til_zeros_iv #10000{}%
87 \def\xint_gob_til_one #11{}%
88 \def\xint_gob_til_G #1G{}%
89 \def\xint_gob_til_minus #1-{}%
90 \def\xint_gob_til_relax #1\relax {}%
91 \def\xint_exchangetwo_keepbraces #1#2{{#2}{#1}}%
92 \def\xint_exchangetwo_keepbraces_thenstop #1#2{ {#2}{#1}}%
93 \def\xint_UDzerofork #10#2#3\krof {#2}%
94 \def\xint_UDsignfork #1-#2#3\krof {#2}%
95 \def\xint_UDwfork #1\W#2#3\krof {#2}%
96 \def\xint_UDzerosfork #100#2#3\krof {#2}%
97 \def\xint_UDonezerofork #110#2#3\krof {#2}%
98 \def\xint_UDzerominusfork #10-#2#3\krof {#2}%
99 \def\xint_UDsignsfork #1--#2#3\krof {#2}%
100% \chardef\xint_c_ 0 % already done in xinttools

```

```

101 \chardef\xint_c_i      1
102 \chardef\xint_c_ii    2
103 \chardef\xint_c_iii   3
104 \chardef\xint_c_iv    4
105 \chardef\xint_c_v     5
106 % \chardef\xint_c_vi   6 % will be done in xintfrac
107 % \chardef\xinf_c_vii  7 % will be done in xintfrac
108 % \chardef\xint_c_viii 8 % already done in xinttools
109 \chardef\xint_c_ix     9
110 \chardef\xint_c_x     10
111 \chardef\xint_c_ii^v   32 % not used in xint, common to xintfrac and xintbinhex
112 \chardef\xint_c_ii^vi 64
113 \mathchardef\xint_c_ixixixix 9999
114 \mathchardef\xint_c_x^iv 10000
115 \newcount\xint_c_x^viii \xint_c_x^viii 100000000

```

### 36.6 \xintRev

\xintRev: expands fully its argument \romannumeral-‘0, and checks the sign. However this last aspect does not appear like a very useful thing. And despite the fact that a special check is made for a sign, actually the input is not given to \xintnum, contrarily to \xintLen. This is all a bit incoherent. Should be fixed.

```

116 \def\xintRev {\romannumeral0\xintrev }%
117 \def\xintrev #1%
118 {%
119   \expandafter\XINT_rev_fork
120   \romannumeral-‘0#1\xint_relax % empty #1 ok, \xint_relax stops expansion
121   \xint_bye\xint_bye\xint_bye\xint_bye
122   \xint_bye\xint_bye\xint_bye\xint_bye
123   \xint_relax
124 }%
125 \def\XINT_rev_fork #1%
126 {%
127   \xint_UDsignfork
128   #1{\expandafter\xint_minus_thenstop\romannumeral0\XINT_rord_main {}}%
129   -{\XINT_rord_main {}}#1}%
130   \krof
131 }%

```

### 36.7 \xintLen

\xintLen is ONLY for (possibly long) integers. Gets extended to fractions by xintfrac.sty

```

132 \def\xintLen {\romannumeral0\xintlen }%
133 \def\xintlen #1%
134 {%
135   \expandafter\XINT_len_fork

```

```

136 \romannumeral0\xintnum{#1}\xint_relax\xint_relax\xint_relax\xint_relax
137 \xint_relax\xint_relax\xint_relax\xint_relax\xint_bye
138 }%
139 \def\xINT_Len #1% variant which does not expand via \xintnum.
140 {%
141 \romannumeral0\xINT_len_fork
142 #1\xint_relax\xint_relax\xint_relax\xint_relax
143 \xint_relax\xint_relax\xint_relax\xint_relax\xint_bye
144 }%
145 \def\xINT_len_fork #1%
146 {%
147 \expandafter\xINT_length_loop
148 \xint_UDsignfork
149 #1{{0}}%
150 -{{0}}#1}%
151 \krof
152 }%

```

### 36.8 \XINT\_RQ

cette macro renverse et ajoute le nombre minimal de zéros à la fin pour que la longueur soit alors multiple de 4

\romannumeral0\xINT\_RQ {}<le truc à renverser>\R\R\R\R\R\R\R\Z

Attention, ceci n'est utilisé que pour des chaînes de chiffres, et donc le comportement avec des {...} ou autres espaces n'a fait l'objet d'aucune attention

```

153 \def\xINT_RQ #1#2#3#4#5#6#7#8#9%
154 {%
155 \xint_gob_til_R #9\xINT_RQ_end_a\R\xINT_RQ {#9#8#7#6#5#4#3#2#1}%
156 }%
157 \def\xINT_RQ_end_a\R\xINT_RQ #1#2\Z
158 {%
159 \XINT_RQ_end_b #1\Z
160 }%
161 \def\xINT_RQ_end_b #1#2#3#4#5#6#7#8%
162 {%
163 \xint_gob_til_R
164 #8\xINT_RQ_end_viii
165 #7\xINT_RQ_end_vii
166 #6\xINT_RQ_end_vi
167 #5\xINT_RQ_end_v
168 #4\xINT_RQ_end_iv
169 #3\xINT_RQ_end_iii
170 #2\xINT_RQ_end_ii
171 \R\xINT_RQ_end_i
172 \Z #2#3#4#5#6#7#8%
173 }%
174 \def\xINT_RQ_end_viii #1\Z #2#3#4#5#6#7#8#9\Z { #9}%
175 \def\xINT_RQ_end_vii #1\Z #2#3#4#5#6#7#8#9\Z { #8#9000}%

```

### 36 Package *xint* implementation

```

176 \def\XINT_RQ_end_vi    #1\Z #2#3#4#5#6#7#8#9\Z { #7#8#900}%
177 \def\XINT_RQ_end_v    #1\Z #2#3#4#5#6#7#8#9\Z { #6#7#8#90}%
178 \def\XINT_RQ_end_iv   #1\Z #2#3#4#5#6#7#8#9\Z { #5#6#7#8#9}%
179 \def\XINT_RQ_end_iii  #1\Z #2#3#4#5#6#7#8#9\Z { #4#5#6#7#8#9000}%
180 \def\XINT_RQ_end_ii   #1\Z #2#3#4#5#6#7#8#9\Z { #3#4#5#6#7#8#900}%
181 \def\XINT_RQ_end_i     \Z #1#2#3#4#5#6#7#8\Z { #1#2#3#4#5#6#7#80}%
182 \def\XINT_SQ #1#2#3#4#5#6#7#8%
183 {%
184   \xint_gob_til_R #8\XINT_SQ_end_a\R\XINT_SQ {#8#7#6#5#4#3#2#1}%
185 }%
186 \def\XINT_SQ_end_a\R\XINT_SQ #1#2\Z
187 {%
188   \XINT_SQ_end_b #1\Z
189 }%
190 \def\XINT_SQ_end_b #1#2#3#4#5#6#7%
191 {%
192   \xint_gob_til_R
193     #7\XINT_SQ_end_vii
194     #6\XINT_SQ_end_vi
195     #5\XINT_SQ_end_v
196     #4\XINT_SQ_end_iv
197     #3\XINT_SQ_end_iii
198     #2\XINT_SQ_end_ii
199     \R\XINT_SQ_end_i
200     \Z #2#3#4#5#6#7%
201 }%
202 \def\XINT_SQ_end_vii  #1\Z #2#3#4#5#6#7#8\Z { #8}%
203 \def\XINT_SQ_end_vi   #1\Z #2#3#4#5#6#7#8\Z { #7#80000000}%
204 \def\XINT_SQ_end_v    #1\Z #2#3#4#5#6#7#8\Z { #6#7#8000000}%
205 \def\XINT_SQ_end_iv   #1\Z #2#3#4#5#6#7#8\Z { #5#6#7#800000}%
206 \def\XINT_SQ_end_iii  #1\Z #2#3#4#5#6#7#8\Z { #4#5#6#7#8000}%
207 \def\XINT_SQ_end_ii   #1\Z #2#3#4#5#6#7#8\Z { #3#4#5#6#7#800}%
208 \def\XINT_SQ_end_i     \Z #1#2#3#4#5#6#7\Z { #1#2#3#4#5#6#70}%
209 \def\XINT_OQ #1#2#3#4#5#6#7#8#9%
210 {%
211   \xint_gob_til_R #9\XINT_OQ_end_a\R\XINT_OQ {#9#8#7#6#5#4#3#2#1}%
212 }%
213 \def\XINT_OQ_end_a\R\XINT_OQ #1#2\Z
214 {%
215   \XINT_OQ_end_b #1\Z
216 }%
217 \def\XINT_OQ_end_b #1#2#3#4#5#6#7#8%
218 {%
219   \xint_gob_til_R
220     #8\XINT_OQ_end_viii
221     #7\XINT_OQ_end_vii
222     #6\XINT_OQ_end_vi
223     #5\XINT_OQ_end_v
224     #4\XINT_OQ_end_iv

```

```

225      #3\XINT_OQ_end_iii
226      #2\XINT_OQ_end_ii
227      \R\XINT_OQ_end_i
228      \Z #2#3#4#5#6#7#8%
229 }%
230 \def\XINT_OQ_end_viii #1\Z #2#3#4#5#6#7#8#9\Z { #9}%
231 \def\XINT_OQ_end_vii #1\Z #2#3#4#5#6#7#8#9\Z { #8#90000000}%
232 \def\XINT_OQ_end_vi #1\Z #2#3#4#5#6#7#8#9\Z { #7#8#90000000}%
233 \def\XINT_OQ_end_v #1\Z #2#3#4#5#6#7#8#9\Z { #6#7#8#9000000}%
234 \def\XINT_OQ_end_iv #1\Z #2#3#4#5#6#7#8#9\Z { #5#6#7#8#90000}%
235 \def\XINT_OQ_end_iii #1\Z #2#3#4#5#6#7#8#9\Z { #4#5#6#7#8#9000}%
236 \def\XINT_OQ_end_ii #1\Z #2#3#4#5#6#7#8#9\Z { #3#4#5#6#7#8#900}%
237 \def\XINT_OQ_end_i #1\Z #2#3#4#5#6#7#8#9\Z { #1#2#3#4#5#6#7#80}%

```

### 36.9 \XINT\_cuz

```

238 \edef\xint_cleanupzeros_andstop #1#2#3#4%
239 {%
240   \noexpand\expandafter\space\noexpand\the\numexpr #1#2#3#4\relax
241 }%
242 \def\xint_cleanupzeros_nostop #1#2#3#4%
243 {%
244   \the\numexpr #1#2#3#4\relax
245 }%
246 \def\XINT_rev_andcuz #1%
247 {%
248   \expandafter\xint_cleanupzeros_andstop
249   \romannumeral0\XINT_rord_main {}#1%
250   \xint_relax
251   \xint_bye\xint_bye\xint_bye\xint_bye
252   \xint_bye\xint_bye\xint_bye\xint_bye
253   \xint_relax
254 }%

```

routine CleanUpZeros. Utilisée en particulier par la soustraction.

INPUT: longueur \*\*multiple de 4\*\* (<-- ATTENTION)

OUTPUT: on a retiré tous les leading zéros, on n'est \*\*plus\*\* nécessairement de longueur 4n

Délimiteur pour \_main: \W\W\W\W\W\W\W\Z avec SEPT \W

```

255 \def\XINT_cuz #1%
256 {%
257   \XINT_cuz_loop #1\W\W\W\W\W\W\W\Z%
258 }%
259 \def\XINT_cuz_loop #1#2#3#4#5#6#7#8%
260 {%
261   \xint_gob_til_W #8\xint_cuz_end_a\W
262   \xint_gob_til_Z #8\xint_cuz_end_A\Z
263   \XINT_cuz_check_a {#1#2#3#4#5#6#7#8}%
264 }%

```

```

265 \def\xint_cuz_end_a #1\XINT_cuz_check_a #2%
266 {%
267   \xint_cuz_end_b #2%
268 }%
269 \edef\xint_cuz_end_b #1#2#3#4#5\Z
270 {%
271   \noexpand\expandafter\space\noexpand\the\numexpr #1#2#3#4\relax
272 }%
273 \def\xint_cuz_end_A \Z\XINT_cuz_check_a #1{ 0}%
274 \def\XINT_cuz_check_a #1%
275 {%
276   \expandafter\XINT_cuz_check_b\the\numexpr #1\relax
277 }%
278 \def\XINT_cuz_check_b #1%
279 {%
280   \xint_gob_til_zero #1\xint_cuz_backtoloop 0\XINT_cuz_stop #1%
281 }%
282 \def\XINT_cuz_stop #1\W #2\Z{ #1}%
283 \def\xint_cuz_backtoloop 0\XINT_cuz_stop 0{\XINT_cuz_loop }%

```

### 36.10 \xintIsOne

Added in 1.03. Attention: \XINT\_isOne does not do any expansion. Release 1.09a defines \xintIsOne which is more user-friendly. Will be modified if xintfrac is loaded.

```

284 \def\xintIsOne {\romannumeral0\xintisone }%
285 \def\xintisone #1{\expandafter\XINT_isone\romannumeral0\xintnum{#1}\W\Z }%
286 \def\XINT_isOne #1{\romannumeral0\XINT_isone #1\W\Z }%
287 \def\XINT_isone #1#2%
288 {%
289   \xint_gob_til_one #1\XINT_isone_b 1%
290   \expandafter\space\expandafter 0\xint_gob_til_Z #2%
291 }%
292 \def\XINT_isone_b #1\xint_gob_til_Z #2%
293 {%
294   \xint_gob_til_W #2\XINT_isone_yes \W
295   \expandafter\space\expandafter 0\xint_gob_til_Z
296 }%
297 \def\XINT_isone_yes #1\Z { 1}%

```

### 36.11 \xintNum

For example \xintNum {-----+-----000000000000003}

1.05 defines \xintiNum, which allows redefinition of \xintNum by xintfrac.sty. Slightly modified in 1.06b (\R->\xint\_relax) to avoid initial re-scan of input stack (while still allowing empty #1). In versions earlier than 1.09a it was entirely up to the user to apply \xintnum; starting with 1.09a arithmetic macros of xint.sty (like earlier already xintfrac.sty with its own \xintnum) make use of

`\xintnum`. This allows arguments to be count registers, or even `\numexpr` arbitrary long expressions (with the trick of braces, see the user documentation).

```

298 \def\xintiNum {\romannumeral0\xintinum }%
299 \def\xintinum #1%
300 {%
301   \expandafter\XINT_num_loop
302   \romannumeral-‘0#1\xint_relax\xint_relax\xint_relax\xint_relax
303   \xint_relax\xint_relax\xint_relax\xint_relax\Z
304 }%
305 \let\xintNum\xintiNum \let\xintnum\xintinum
306 \def\XINT_num #1%
307 {%
308   \XINT_num_loop #1\xint_relax\xint_relax\xint_relax\xint_relax
309   \xint_relax\xint_relax\xint_relax\xint_relax\Z
310 }%
311 \def\XINT_num_loop #1#2#3#4#5#6#7#8%
312 {%
313   \xint_gob_til_xint_relax #8\XINT_num_end\xint_relax
314   \XINT_num_NumEight #1#2#3#4#5#6#7#8%
315 }%
316 \edef\XINT_num_end\xint_relax\XINT_num_NumEight #1\xint_relax #2\Z
317 {%
318   \noexpand\expandafter\space\noexpand\the\numexpr #1+0\relax
319 }%
320 \def\XINT_num_NumEight #1#2#3#4#5#6#7#8%
321 {%
322   \ifnum \numexpr #1#2#3#4#5#6#7#8+0= 0
323     \xint_afterfi {\expandafter\XINT_num_keepsign_a
324     \the\numexpr #1#2#3#4#5#6#7#81\relax}%
325   \else
326     \xint_afterfi {\expandafter\XINT_num_finish
327     \the\numexpr #1#2#3#4#5#6#7#8\relax}%
328   \fi
329 }%
330 \def\XINT_num_keepsign_a #1%
331 {%
332   \xint_gob_til_one#1\XINT_num_gobackto loop 1\XINT_num_keepsign_b
333 }%
334 \def\XINT_num_gobackto loop 1\XINT_num_keepsign_b {\XINT_num_loop }%
335 \def\XINT_num_keepsign_b #1{\XINT_num_loop -}%
336 \def\XINT_num_finish #1\xint_relax #2\Z { #1}%

```

### 36.12 `\xintSgn`, `\xintiiSgn`, `\XINT_Sgn`, `\XINT_cntSgn`

Changed in 1.05. Earlier code was unnecessarily strange. 1.09a with `\xintnum` 1.09i defines `\XINT_Sgn` and `\XINT_cntSgn` (was `\XINT__Sgn` in 1.09i) for reasons of internal optimizations

```

337 \def\xintiisgn {\romannumeral0\xintiisgn }%
338 \def\xintiisgn #1%
339 {%
340   \expandafter\XINT_sgn \romannumeral-‘0#1\Z%
341 }%
342 \def\xintSgn {\romannumeral0\xintsgn }%
343 \def\xintsgn #1%
344 {%
345   \expandafter\XINT_sgn \romannumeral0\xintnum{#1}\Z%
346 }%
347 \def\XINT_sgn #1#2\Z
348 {%
349   \xint_UDzerominusfork
350   #1-{ 0}%
351   0#1{ -1}%
352   0-{ 1}%
353   \krof
354 }%
355 \def\XINT_Sgn #1#2\Z
356 {%
357   \xint_UDzerominusfork
358   #1-{0}%
359   0#1{-1}%
360   0-{1}%
361   \krof
362 }%
363 \def\XINT_cntSgn #1#2\Z
364 {%
365   \xint_UDzerominusfork
366   #1-\z@
367   0#1\m@ne
368   0-\@ne
369   \krof
370 }%

```

### 36.13 \xintBool, \xintToggle

1.09c

```

371 \def\xintBool #1{\romannumeral-‘0%
372   \csname if#1\endcsname\expandafter1\else\expandafter0\fi }%
373 \def\xintToggle #1{\romannumeral-‘0\iftoggle{#1}{1}{0}}%

```

### 36.14 \xintSgnFork

Expandable three-way fork added in 1.07. The argument #1 must expand to -1,0 or 1. 1.09i has `_afterstop`, renamed `_thenstop` later, for efficiency.

```

374 \def\xintSgnFork {\romannumeral0\xintsgnfork }%
375 \def\xintsgnfork #1%
376 {%
377     \ifcase #1 \expandafter\xint_secondofthree_thenstop
378             \or\expandafter\xint_thirdofthree_thenstop
379             \else\expandafter\xint_firstofthree_thenstop
380     \fi
381 }%

```

### 36.15 \XINT\_cntSgnFork

1.09i. Used internally, #1 must expand to \m@ne, \z@, or \@ne or equivalent. Does not insert a space token to stop a romannumeral0 expansion.

```

382 \def\XINT_cntSgnFork #1%
383 {%
384     \ifcase #1\expandafter\xint_secondofthree
385             \or\expandafter\xint_thirdofthree
386             \else\expandafter\xint_firstofthree
387     \fi
388 }%

```

### 36.16 \xintifSgn

Expandable three-way fork added in 1.09a. Branches expandably depending on whether <0, =0, >0. Choice of branch guaranteed in two steps.

The use of \romannumeral0\xintsgn rather than \xintSgn is for matters related to the transformation of the ternary operator : in \xintNewExpr. I hope I have explained there the details because right now off hand I can't recall why.

1.09i has \xint\_firstofthreeafterstop (now \_thenstop) etc for faster expansion.

```

389 \def\xintifSgn {\romannumeral0\xintifsgn }%
390 \def\xintifsgn #1%
391 {%
392     \ifcase \romannumeral0\xintsgn{#1}
393             \expandafter\xint_secondofthree_thenstop
394             \or\expandafter\xint_thirdofthree_thenstop
395             \else\expandafter\xint_firstofthree_thenstop
396     \fi
397 }%

```

### 36.17 \xintifZero, \xintifNotZero

Expandable two-way fork added in 1.09a. Branches expandably depending on whether the argument is zero (branch A) or not (branch B). 1.09i restyling. By the way it appears (not thoroughly tested, though) that \if tests are faster than \ifnum tests.

```

398 \def\xintifZero {\romannumeral0\xintifzero }%
399 \def\xintifzero #1%
400 {%
401   \if0\xintSgn{#1}%
402     \expandafter\xint_firstoftwo_thenstop
403   \else
404     \expandafter\xint_secondoftwo_thenstop
405   \fi
406 }%
407 \def\xintifNotZero {\romannumeral0\xintifnotzero }%
408 \def\xintifnotzero #1%
409 {%
410   \if0\xintSgn{#1}%
411     \expandafter\xint_secondoftwo_thenstop
412   \else
413     \expandafter\xint_firstoftwo_thenstop
414   \fi
415 }%

```

### 36.18 \xintifOne

added in 1.09i.

```

416 \def\xintifOne {\romannumeral0\xintifone }%
417 \def\xintifone #1%
418 {%
419   \if1\xintIsOne{#1}%
420     \expandafter\xint_firstoftwo_thenstop
421   \else
422     \expandafter\xint_secondoftwo_thenstop
423   \fi
424 }%

```

### 36.19 \xintifTrueAelseB, \xintifFalseAelseB

1.09i. Warning, \xintifTrueFalse, \xintifTrue deprecated, to be removed

```

425 \let\xintifTrueAelseB\xintifNotZero
426 \let\xintifFalseAelseB\xintifZero
427 \let\xintifTrue\xintifNotZero
428 \let\xintifTrueFalse\xintifNotZero

```

### 36.20 \xintifCmp

1.09e \xintifCmp {n}{m}{if n<m}{if n=m}{if n>m}.

```

429 \def\xintifCmp {\romannumeral0\xintifcmp }%
430 \def\xintifcmp #1#2%

```

```

431 {%
432   \ifcase\xintCmp {#1}{#2}
433     \expandafter\xint_secondofthree_thenstop
434     \or\expandafter\xint_thirdofthree_thenstop
435     \else\expandafter\xint_firstofthree_thenstop
436   \fi
437 }%

```

### 36.21 \xintifEq

1.09a \xintifEq {n}{m}{YES if n=m}{NO if n<>m}.

```

438 \def\xintifEq {\romannumeral0\xintifeq }%
439 \def\xintifeq #1#2%
440 {%
441   \if0\xintCmp{#1}{#2}%
442     \expandafter\xint_firstoftwo_thenstop
443     \else\expandafter\xint_secondoftwo_thenstop
444   \fi
445 }%

```

### 36.22 \xintifGt

1.09a \xintifGt {n}{m}{YES if n>m}{NO if n<=m}.

```

446 \def\xintifGt {\romannumeral0\xintifgt }%
447 \def\xintifgt #1#2%
448 {%
449   \if1\xintCmp{#1}{#2}%
450     \expandafter\xint_firstoftwo_thenstop
451     \else\expandafter\xint_secondoftwo_thenstop
452   \fi
453 }%

```

### 36.23 \xintifLt

1.09a \xintifLt {n}{m}{YES if n<m}{NO if n>=m}. Restyled in 1.09i

```

454 \def\xintifLt {\romannumeral0\xintiflt }%
455 \def\xintiflt #1#2%
456 {%
457   \ifnum\xintCmp{#1}{#2}<\xint_c_
458     \expandafter\xint_firstoftwo_thenstop
459   \else \expandafter\xint_secondoftwo_thenstop
460   \fi
461 }%

```

**36.24 \xintifOdd**

1.09e. Restyled in 1.09i.

```

462 \def\xintifOdd {\romannumeral0\xintifodd}%
463 \def\xintifodd #1%
464 {%
465   \if\xintOdd{#1}1%
466   \expandafter\xint_firstoftwo_thenstop
467   \else
468   \expandafter\xint_secondoftwo_thenstop
469   \fi
470}%

```

**36.25 \xintOpp**

\xintnum added in 1.09a

```

471 \def\xintiiOpp {\romannumeral0\xintiiopp}%
472 \def\xintiiopp #1%
473 {%
474   \expandafter\XINT_opp \romannumeral-‘0#1%
475}%
476 \def\xintiOpp {\romannumeral0\xintiopp}%
477 \def\xintiopp #1%
478 {%
479   \expandafter\XINT_opp \romannumeral0\xintnum{#1}%
480}%
481 \let\xintOpp\xintiOpp \let\xintopp\xintiopp
482 \def\XINT_Opp #1{\romannumeral0\XINT_opp #1}%
483 \def\XINT_opp #1%
484 {%
485   \xint_UDzerominusfork
486   #1-{ 0}%      zero
487   0#1{ }%      negative
488   0-{ -#1}%    positive
489   \krof
490}%

```

**36.26 \xintAbs**

Release 1.09a has now \xintiabs which does \xintnum (contrarily to some other i-macros, but similarly as \xintiAdd etc...) and this is inherited by DecSplit, by Sqr, and macros of xintgcd.sty.

```

491 \def\xintiiAbs {\romannumeral0\xintiiabs}%
492 \def\xintiiabs #1%
493 {%
494   \expandafter\XINT_abs \romannumeral-‘0#1%

```

```

495 }%
496 \def\xintiAbs {\romannumeral0\xintiabs }%
497 \def\xintiabs #1%
498 {%
499   \expandafter\XINT_abs \romannumeral0\xintnum{#1}%
500 }%
501 \let\xintAbs\xintiAbs \let\xintabs\xintiabs
502 \def\XINT_Abs #1{\romannumeral0\XINT_abs #1}%
503 \def\XINT_abs #1%
504 {%
505   \xint_UDsignfork
506     #1{ }%
507     -{ #1}%
508   \krof
509 }%

```

-----  
 ARITHMETIC OPERATIONS: ADDITION, SUBTRACTION, SUMS, MULTIPLICATION, PRODUCTS, FACTORIAL, POWERS, EUCLIDEAN DIVISION.

Release 1.03 re-organizes sub-routines to facilitate future developments: the diverse variants of addition, with diverse conditions on inputs and output are first listed; they will be used in multiplication, or in the summation, or in the power routines. I am aware that the commenting is close to non-existent, sorry about that.

ADDITION I: \XINT\_add\_A

INPUT:

\romannumeral0\XINT\_add\_A 0{<N1>\W\X\Y\Z <N2>\W\X\Y\Z

1. <N1> et <N2> renversés
2. de longueur 4n (avec des leading zéros éventuels)
3. l'un des deux ne doit pas se terminer par 0000

[Donc on peut avoir 0000 comme input si l'autre est >0 et ne se termine pas en 0000 bien sûr]. On peut avoir l'un des deux vides. Mais alors l'autre ne doit être ni vide ni 0000.

OUTPUT: la somme <N1>+<N2>, ordre normal, plus sur 4n, pas de leading zeros La procédure est plus rapide lorsque <N1> est le plus court des deux.

Nota bene: (30 avril 2013). J'ai une version qui est deux fois plus rapide sur des nombres d'environ 1000 chiffres chacun, et qui commence à être avantageuse pour des nombres d'au moins 200 chiffres. Cependant il serait vraiment compliqué d'en étendre l'utilisation aux emplois de l'addition dans les autres routines, comme celle de multiplication ou celle de division; et son implémentation ajouterait au minimum la mesure de la longueur des summands.

```

510 \def\XINT_add_A #1#2#3#4#5#6%
511 {%
512   \xint_gob_til_W #3\xint_add_az\W
513   \XINT_add_AB #1{#3#4#5#6}{#2}%
514 }%
515 \def\xint_add_az\W\XINT_add_AB #1#2%

```

```

516 {%
517   \XINT_add_AC_checkcarry #1%
518 }%

```

ici #2 est prévu pour l'addition, mais attention il devra être renversé pour \numexpr. #3 = résultat partiel. #4 = chiffres qui restent. On vérifie si le deuxième nombre s'arrête.

```

519 \def\XINT_add_AB #1#2#3#4\W\X\Y\Z #5#6#7#8%
520 {%
521   \xint_gob_til_W #5\xint_add_bz\W
522   \XINT_add_ABE #1#2{#8#7#6#5}{#3}#4\W\X\Y\Z
523 }%
524 \def\XINT_add_ABE #1#2#3#4#5#6%
525 {%
526   \expandafter\XINT_add_ABEA\the\numexpr #1+10#5#4#3#2+#6.%
527 }%
528 \def\XINT_add_ABEA #1#2#3.#4%
529 {%
530   \XINT_add_A #2{#3#4}%
531 }%

```

ici le deuxième nombre est fini #6 part à la poubelle, #2#3#4#5 est le #2 dans \XINT\_add\_AB on ne vérifie pas la retenue cette fois, mais les fois suivantes

```

532 \def\xint_add_bz\W\XINT_add_ABE #1#2#3#4#5#6%
533 {%
534   \expandafter\XINT_add_CC\the\numexpr #1+10#5#4#3#2.%
535 }%
536 \def\XINT_add_CC #1#2#3.#4%
537 {%
538   \XINT_add_AC_checkcarry #2{#3#4}% on va examiner et \'eliminer #2
539 }%

```

retenue plus chiffres qui restent de l'un des deux nombres. #2 = résultat partiel #3#4#5#6 = summand, avec plus significatif à droite

```

540 \def\XINT_add_AC_checkcarry #1%
541 {%
542   \xint_gob_til_zero #1\xint_add_AC_nocarry 0\XINT_add_C
543 }%
544 \def\xint_add_AC_nocarry 0\XINT_add_C #1#2\W\X\Y\Z
545 {%
546   \expandafter
547   \xint_cleanupzeros_andstop
548   \romannumeral0%
549   \XINT_rord_main {}#2%
550   \xint_relax
551   \xint_bye\xint_bye\xint_bye\xint_bye
552   \xint_bye\xint_bye\xint_bye\xint_bye

```

```

553     \xint_relax
554     #1%
555 }%
556 \def\xINT_add_C #1#2#3#4#5%
557 {%
558     \xint_gob_til_W #2\xint_add_cz\W
559     \XINT_add_CD {#5#4#3#2}{#1}%
560 }%
561 \def\xINT_add_CD #1%
562 {%
563     \expandafter\xINT_add_CC\the\numexpr 1+10#1.%
564 }%
565 \def\xint_add_cz\W\xINT_add_CD #1#2{ 1#2}%

Addition II: \XINT_addr_A.
INPUT: \romannumeral0\xINT_addr_A 0{}<N1>\W\X\Y\Z <N2>\W\X\Y\Z
    Comme \XINT_add_A, la différence principale c'est qu'elle donne son résultat
    aussi *sur 4n*, renversé. De plus cette variante accepte que l'un ou même les
    deux inputs soient vides. Utilisé par la sommation et par la division (pour les
    quotients). Et aussi par la multiplication d'ailleurs.
INPUT: comme pour \XINT_add_A
1. <N1> et <N2> renversés
2. de longueur 4n (avec des leading zéros éventuels)
3. l'un des deux ne doit pas se terminer par 0000
OUTPUT: la somme <N1>+<N2>, *aussi renversée* et *sur 4n*

566 \def\xINT_addr_A #1#2#3#4#5#6%
567 {%
568     \xint_gob_til_W #3\xint_addr_az\W
569     \XINT_addr_B #1{#3#4#5#6}{#2}%
570 }%
571 \def\xint_addr_az\W\xINT_addr_B #1#2%
572 {%
573     \XINT_addr_AC_checkcarry #1%
574 }%
575 \def\xINT_addr_B #1#2#3#4\W\X\Y\Z #5#6#7#8%
576 {%
577     \xint_gob_til_W #5\xint_addr_bz\W
578     \XINT_addr_E #1#2{#8#7#6#5}{#3}#4\W\X\Y\Z
579 }%
580 \def\xINT_addr_E #1#2#3#4#5#6%
581 {%
582     \expandafter\xINT_addr_ABEA\the\numexpr #1+10#5#4#3#2+#6\relax
583 }%
584 \def\xINT_addr_ABEA #1#2#3#4#5#6#7%
585 {%
586     \XINT_addr_A #2{#7#6#5#4#3}%
587 }%
588 \def\xint_addr_bz\W\xINT_addr_E #1#2#3#4#5#6%
589 {%

```

### 36 Package *xint* implementation

```

590 \expandafter\XINT_addr_CC\the\numexpr #1+10#5#4#3#2\relax
591 }%
592 \def\XINT_addr_CC #1#2#3#4#5#6#7%
593 {%
594 \XINT_addr_AC_checkcarry #2{#7#6#5#4#3}%
595 }%
596 \def\XINT_addr_AC_checkcarry #1%
597 {%
598 \xint_gob_til_zero #1\xint_addr_AC_nocarry 0\XINT_addr_C
599 }%
600 \def\xint_addr_AC_nocarry 0\XINT_addr_C #1#2\W\X\Y\Z { #1#2}%
601 \def\XINT_addr_C #1#2#3#4#5%
602 {%
603 \xint_gob_til_W #2\xint_addr_cz\W
604 \XINT_addr_D {#5#4#3#2}{#1}%
605 }%
606 \def\XINT_addr_D #1%
607 {%
608 \expandafter\XINT_addr_CC\the\numexpr 1+10#1\relax
609 }%
610 \def\xint_addr_cz\W\XINT_addr_D #1#2{ #21000}%

ADDITION III, \XINT_addm_A
INPUT:\romannumeral0\XINT_addm_A 0{<N1>\W\X\Y\Z <N2>\W\X\Y\Z
1. <N1> et <N2> renversés
2. <N1> de longueur 4n ; <N2> non
3. <N2> est *garanti au moins aussi long* que <N1>
OUTPUT: la somme <N1>+<N2>, ordre normal, pas sur 4n, leading zeros retirés. Util-
isé par la multiplication.

611 \def\XINT_addm_A #1#2#3#4#5#6%
612 {%
613 \xint_gob_til_W #3\xint_addm_az\W
614 \XINT_addm_AB #1{#3#4#5#6}{#2}%
615 }%
616 \def\xint_addm_az\W\XINT_addm_AB #1#2%
617 {%
618 \XINT_addm_AC_checkcarry #1%
619 }%
620 \def\XINT_addm_AB #1#2#3#4\W\X\Y\Z #5#6#7#8%
621 {%
622 \XINT_addm_ABE #1#2{#8#7#6#5}{#3}#4\W\X\Y\Z
623 }%
624 \def\XINT_addm_ABE #1#2#3#4#5#6%
625 {%
626 \expandafter\XINT_addm_ABEA\the\numexpr #1+10#5#4#3#2+#6.%
627 }%
628 \def\XINT_addm_ABEA #1#2#3.#4%
629 {%
630 \XINT_addm_A #2{#3#4}%

```

```

631 }%
632 \def\XINT_addm_AC_checkcarry #1%
633 {%
634   \xint_gob_til_zero #1\xint_addm_AC_nocarry 0\XINT_addm_C
635 }%
636 \def\xint_addm_AC_nocarry 0\XINT_addm_C #1#2\W\X\Y\Z
637 {%
638   \expandafter
639   \xint_cleanupzeros_andstop
640   \romannumeral0%
641   \XINT_rord_main {}#2%
642   \xint_relax
643   \xint_bye\xint_bye\xint_bye\xint_bye
644   \xint_bye\xint_bye\xint_bye\xint_bye
645   \xint_relax
646   #1%
647 }%
648 \def\XINT_addm_C #1#2#3#4#5%
649 {%
650   \xint_gob_til_W
651   #5\xint_addm_cw
652   #4\xint_addm_cx
653   #3\xint_addm_cy
654   #2\xint_addm_cz
655   \W\XINT_addm_CD {#5#4#3#2}{#1}%
656 }%
657 \def\XINT_addm_CD #1%
658 {%
659   \expandafter\XINT_addm_CC\the\numexpr 1+10#1.%
660 }%
661 \def\XINT_addm_CC #1#2#3.#4%
662 {%
663   \XINT_addm_AC_checkcarry #2{#3#4}%
664 }%
665 \def\xint_addm_cw
666   #1\xint_addm_cx
667   #2\xint_addm_cy
668   #3\xint_addm_cz
669   \W\XINT_addm_CD
670 {%
671   \expandafter\XINT_addm_CDw\the\numexpr 1+#1#2#3.%
672 }%
673 \def\XINT_addm_CDw #1.#2#3\X\Y\Z
674 {%
675   \XINT_addm_end #1#3%
676 }%
677 \def\xint_addm_cx
678   #1\xint_addm_cy
679   #2\xint_addm_cz

```

```

680 \W\XINT_addm_CD
681 {%
682 \expandafter\XINT_addm_CDx\the\numexpr 1+#1#2.%
683 }%
684 \def\XINT_addm_CDx #1.#2#3\Y\Z
685 {%
686 \XINT_addm_end #1#3%
687 }%
688 \def\xint_addm_cy
689 #1\xint_addm_cz
690 \W\XINT_addm_CD
691 {%
692 \expandafter\XINT_addm_CDy\the\numexpr 1+#1.%
693 }%
694 \def\XINT_addm_CDy #1.#2#3\Z
695 {%
696 \XINT_addm_end #1#3%
697 }%
698 \def\xint_addm_cz\W\XINT_addm_CD #1#2#3{\XINT_addm_end #1#3}%
699 \edef\XINT_addm_end #1#2#3#4#5%
700 {\noexpand\expandafter\space\noexpand\the\numexpr #1#2#3#4#5\relax}%

ADDITION IV, variante \XINT_addp_A
INPUT: \romannumeral0\XINT_addp_A 0{}<N1>\W\X\Y\Z <N2>\W\X\Y\Z
1. <N1> et <N2> renversés
2. <N1> de longueur 4n ; <N2> non
3. <N2> est *garanti au moins aussi long* que <N1>
OUTPUT: la somme <N1>+<N2>, dans l'ordre renversé, sur 4n, et en faisant attention
de ne pas terminer en 0000. Utilisé par la multiplication servant pour le calcul
des puissances.

701 \def\XINT_addp_A #1#2#3#4#5#6%
702 {%
703 \xint_gob_til_W #3\xint_addp_az\W
704 \XINT_addp_AB #1{#3#4#5#6}{#2}%
705 }%
706 \def\xint_addp_az\W\XINT_addp_AB #1#2%
707 {%
708 \XINT_addp_AC_checkcarry #1%
709 }%
710 \def\XINT_addp_AC_checkcarry #1%
711 {%
712 \xint_gob_til_zero #1\xint_addp_AC_nocarry 0\XINT_addp_C
713 }%
714 \def\xint_addp_AC_nocarry 0\XINT_addp_C
715 {%
716 \XINT_addp_F
717 }%
718 \def\XINT_addp_AB #1#2#3#4\W\X\Y\Z #5#6#7#8%
719 {%

```

### 36 Package *xint* implementation

```

720 \XINT_addp_ABE #1#2{#8#7#6#5}{#3}#4\W\X\Y\Z
721 }%
722 \def\XINT_addp_ABE #1#2#3#4#5#6%
723 {%
724 \expandafter\XINT_addp_ABEA\the\numexpr #1+10#5#4#3#2+#6\relax
725 }%
726 \def\XINT_addp_ABEA #1#2#3#4#5#6#7%
727 {%
728 \XINT_addp_A #2{#7#6#5#4#3}%<-- attention on met donc \'a droite
729 }%
730 \def\XINT_addp_C #1#2#3#4#5%
731 {%
732 \xint_gob_til_W
733 #5\xint_addp_cw
734 #4\xint_addp_cx
735 #3\xint_addp_cy
736 #2\xint_addp_cz
737 \W\XINT_addp_CD {#5#4#3#2}{#1}%
738 }%
739 \def\XINT_addp_CD #1%
740 {%
741 \expandafter\XINT_addp_CC\the\numexpr 1+10#1\relax
742 }%
743 \def\XINT_addp_CC #1#2#3#4#5#6#7%
744 {%
745 \XINT_addp_AC_checkcarry #2{#7#6#5#4#3}%
746 }%
747 \def\xint_addp_cw
748 #1\xint_addp_cx
749 #2\xint_addp_cy
750 #3\xint_addp_cz
751 \W\XINT_addp_CD
752 {%
753 \expandafter\XINT_addp_CDw\the\numexpr \xint_c_i+10#1#2#3\relax
754 }%
755 \def\XINT_addp_CDw #1#2#3#4#5#6%
756 {%
757 \xint_gob_til_zeros_iv #2#3#4#5\XINT_addp_endDw_zeros
758 0000\XINT_addp_endDw #2#3#4#5%
759 }%
760 \def\XINT_addp_endDw_zeros 0000\XINT_addp_endDw 0000#1\X\Y\Z{ #1}%
761 \def\XINT_addp_endDw #1#2#3#4#5\X\Y\Z{ #5#4#3#2#1}%
762 \def\xint_addp_cx
763 #1\xint_addp_cy
764 #2\xint_addp_cz
765 \W\XINT_addp_CD
766 {%
767 \expandafter\XINT_addp_CDx\the\numexpr \xint_c_i+100#1#2\relax
768 }%

```

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```

769 \def\XINT_addp_CDx #1#2#3#4#5#6%
770 {%
771     \xint_gob_til_zeros_iv #2#3#4#5\XINT_addp_endDx_zeros
772         0000\XINT_addp_endDx #2#3#4#5%
773 }%
774 \def\XINT_addp_endDx_zeros 0000\XINT_addp_endDx 0000#1\Y\Z{ #1}%
775 \def\XINT_addp_endDx #1#2#3#4#5\Y\Z{ #5#4#3#2#1}%
776 \def\xint_addp_cy #1\xint_addp_cz\W\XINT_addp_CD
777 {%
778     \expandafter\XINT_addp_CDy\the\numexpr \xint_c_i+1000#1\relax
779 }%
780 \def\XINT_addp_CDy #1#2#3#4#5#6%
781 {%
782     \xint_gob_til_zeros_iv #2#3#4#5\XINT_addp_endDy_zeros
783         0000\XINT_addp_endDy #2#3#4#5%
784 }%
785 \def\XINT_addp_endDy_zeros 0000\XINT_addp_endDy 0000#1\Z{ #1}%
786 \def\XINT_addp_endDy #1#2#3#4#5\Z{ #5#4#3#2#1}%
787 \def\xint_addp_cz\W\XINT_addp_CD #1#2{ #21000}%
788 \def\XINT_addp_F #1#2#3#4#5%
789 {%
790     \xint_gob_til_W
791     #5\xint_addp_Gw
792     #4\xint_addp_Gx
793     #3\xint_addp_Gy
794     #2\xint_addp_Gz
795     \W\XINT_addp_G {#2#3#4#5}{#1}%
796 }%
797 \def\XINT_addp_G #1#2%
798 {%
799     \XINT_addp_F {#2#1}%
800 }%
801 \def\xint_addp_Gw
802     #1\xint_addp_Gx
803     #2\xint_addp_Gy
804     #3\xint_addp_Gz
805     \W\XINT_addp_G #4%
806 {%
807     \xint_gob_til_zeros_iv #3#2#10\XINT_addp_endGw_zeros
808         0000\XINT_addp_endGw #3#2#10%
809 }%
810 \def\XINT_addp_endGw_zeros 0000\XINT_addp_endGw 0000#1\X\Y\Z{ #1}%
811 \def\XINT_addp_endGw #1#2#3#4#5\X\Y\Z{ #5#1#2#3#4}%
812 \def\xint_addp_Gx
813     #1\xint_addp_Gy
814     #2\xint_addp_Gz
815     \W\XINT_addp_G #3%
816 {%
817     \xint_gob_til_zeros_iv #2#100\XINT_addp_endGx_zeros

```

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```

818          0000\XINT_addp_endGx #2#100%
819 }%
820 \def\XINT_addp_endGx_zeros 0000\XINT_addp_endGx 0000#1\Y\Z{ #1}%
821 \def\XINT_addp_endGx #1#2#3#4#5\Y\Z{ #5#1#2#3#4}%
822 \def\xint_addp_Gy
823     #1\xint_addp_Gz
824     \W\XINT_addp_G #2%
825 {%
826     \xint_gob_til_zeros_iv #1000\XINT_addp_endGy_zeros
827     0000\XINT_addp_endGy #1000%
828 }%
829 \def\XINT_addp_endGy_zeros 0000\XINT_addp_endGy 0000#1\Z{ #1}%
830 \def\XINT_addp_endGy #1#2#3#4#5\Z{ #5#1#2#3#4}%
831 \def\xint_addp_Gz\W\XINT_addp_G #1#2{ #2}%

```

#### 36.27 \xintAdd

Release 1.09a has \xintnum added into \xintiAdd.

```

832 \def\xintiiAdd {\romannumeral0\xintiiadd }%
833 \def\xintiiadd #1%
834 {%
835     \expandafter\xint_iiadd\expandafter{\romannumeral-‘0#1}%
836 }%
837 \def\xint_iiadd #1#2%
838 {%
839     \expandafter\XINT_add_fork \romannumeral-‘0#2\Z #1\Z
840 }%
841 \def\xintiAdd {\romannumeral0\xintiadd }%
842 \def\xintiadd #1%
843 {%
844     \expandafter\xint_add\expandafter{\romannumeral0\xintnum{#1}}%
845 }%
846 \def\xint_add #1#2%
847 {%
848     \expandafter\XINT_add_fork \romannumeral0\xintnum{#2}\Z #1\Z
849 }%
850 \let\xintAdd\xintiAdd \let\xintadd\xintiadd
851 \def\XINT_Add #1#2{\romannumeral0\XINT_add_fork #2\Z #1\Z }%
852 \def\XINT_add #1#2{\XINT_add_fork #2\Z #1\Z }%

```

ADDITION Ici #1#2 vient du \*deuxième\* argument de \xintAdd et #3#4 donc du \*premier\* [algo plus efficace lorsque le premier est plus long que le second]

```

853 \def\XINT_add_fork #1#2\Z #3#4\Z
854 {%
855     \xint_UDzerofork
856     #1\XINT_add_secondiszero
857     #3\XINT_add_firstiszero

```

```

858      0
859      {\xint_UDsignsfork
860          #1#3\XINT_add_minusminus          % #1 = #3 = -
861          #1-\XINT_add_minusplus            % #1 = -
862          #3-\XINT_add_plusminus            % #3 = -
863          --\XINT_add_plusplus
864          \krof }%
865      \krof
866      {#2}{#4}#1#3%
867 }%
868 \def\XINT_add_secondiszero #1#2#3#4{ #4#2}%
869 \def\XINT_add_firstiszero #1#2#3#4{ #3#1}%

#1 vient du *deuxième* et #2 vient du *premier*

870 \def\XINT_add_minusminus #1#2#3#4%
871 {%
872     \expandafter\xint_minus_thenstop%
873     \romannumeral0\XINT_add_pre {#2}{#1}%
874 }%
875 \def\XINT_add_minusplus #1#2#3#4%
876 {%
877     \XINT_sub_pre {#4#2}{#1}%
878 }%
879 \def\XINT_add_plusminus #1#2#3#4%
880 {%
881     \XINT_sub_pre {#3#1}{#2}%
882 }%
883 \def\XINT_add_plusplus #1#2#3#4%
884 {%
885     \XINT_add_pre {#4#2}{#3#1}%
886 }%
887 \def\XINT_add_pre #1%
888 {%
889     \expandafter\XINT_add_pre_b\expandafter
890     {\romannumeral0\XINT_RQ {}}#1\R\R\R\R\R\R\R\R\Z }%
891 }%
892 \def\XINT_add_pre_b #1#2%
893 {%
894     \expandafter\XINT_add_A
895     \expandafter0\expandafter{\expandafter}%
896     \romannumeral0\XINT_RQ {}}#2\R\R\R\R\R\R\R\R\Z
897     \W\X\Y\Z #1\W\X\Y\Z
898 }%

```

### 36.28 \xintSub

Release 1.09a has \xintnum added into \xintiSub.

```

899 \def\xintiiSub {\romannumeral0\xintiisub }%
900 \def\xintiisub #1%
901 {%
902   \expandafter\xint_iisub\expandafter{\romannumeral-‘0#1}%
903 }%
904 \def\xint_iisub #1#2%
905 {%
906   \expandafter\XINT_sub_fork \romannumeral-‘0#2\Z #1\Z
907 }%
908 \def\xintiSub {\romannumeral0\xintisub }%
909 \def\xintisub #1%
910 {%
911   \expandafter\xint_sub\expandafter{\romannumeral0\xintnum{#1}}%
912 }%
913 \def\xint_sub #1#2%
914 {%
915   \expandafter\XINT_sub_fork \romannumeral0\xintnum{#2}\Z #1\Z
916 }%
917 \def\XINT_Sub #1#2{\romannumeral0\XINT_sub_fork #2\Z #1\Z }%
918 \def\XINT_sub #1#2{\XINT_sub_fork #2\Z #1\Z }%
919 \let\xintSub\xintiSub \let\xintsub\xintisub

SOUSTRACTION #3#4-#1#2: #3#4 vient du *premier* #1#2 vient du *second*

920 \def\XINT_sub_fork #1#2\Z #3#4\Z
921 {%
922   \xint_UDsignsfork
923     #1#3\XINT_sub_minusminus
924     #1-\XINT_sub_minusplus % attention, #3=0 possible
925     #3-\XINT_sub_plusminus % attention, #1=0 possible
926     --{\xint_UDzerofork
927       #1\XINT_sub_secondiszero
928       #3\XINT_sub_firstiszero
929       0\XINT_sub_plusplus
930       \krof }%
931   \krof
932   {#2}{#4}#1#3%
933 }%
934 \def\XINT_sub_secondiszero #1#2#3#4{ #4#2}%
935 \def\XINT_sub_firstiszero #1#2#3#4{ -#3#1}%
936 \def\XINT_sub_plusplus #1#2#3#4%
937 {%
938   \XINT_sub_pre {#4#2}{#3#1}%
939 }%
940 \def\XINT_sub_minusminus #1#2#3#4%
941 {%
942   \XINT_sub_pre {#1}{#2}%
943 }%
944 \def\XINT_sub_minusplus #1#2#3#4%
945 {%

```

```

946 \xint_gob_til_zero #4\xint_sub_mp0\XINT_add_pre {#4#2}{#1}%
947 }%
948 \def\xint_sub_mp0\XINT_add_pre #1#2{ #2}%
949 \def\XINT_sub_plusminus #1#2#3#4%
950 {%
951 \xint_gob_til_zero #3\xint_sub_pm0\expandafter\xint_minus_thenstop%
952 \romannumeral0\XINT_add_pre {#2}{#3#1}%
953 }%
954 \def\xint_sub_pm #1\XINT_add_pre #2#3{ -#2}%
955 \def\XINT_sub_pre #1%
956 {%
957 \expandafter\XINT_sub_pre_b\expandafter
958 {\romannumeral0\XINT_RQ {}}#1\R\R\R\R\R\R\R\R\Z }%
959 }%
960 \def\XINT_sub_pre_b #1#2%
961 {%
962 \expandafter\XINT_sub_A
963 \expandafter1\expandafter{\expandafter}%
964 \romannumeral0\XINT_RQ {}}#2\R\R\R\R\R\R\R\R\Z
965 \W\X\Y\Z #1 \W\X\Y\Z
966 }%

\romannumeral0\XINT_sub_A 1{<N1>\W\X\Y\Z<N2>\W\X\Y\Z
N1 et N2 sont présentés à l'envers ET ON A RAJOUTÉ DES ZÉROS POUR QUE LEURS
LONGUEURS À CHACUN SOIENT MULTIPLES DE 4, MAIS AUCUN NE SE TERMINE EN 0000.
output: N2 - N1
Elle donne le résultat dans le **bon ordre**, avec le bon signe, et sans zéros
superflus.

967 \def\XINT_sub_A #1#2#3\W\X\Y\Z #4#5#6#7%
968 {%
969 \xint_gob_til_W
970 #4\xint_sub_az
971 \W\XINT_sub_B #1{#4#5#6#7}{#2}#3\W\X\Y\Z
972 }%
973 \def\XINT_sub_B #1#2#3#4#5#6#7%
974 {%
975 \xint_gob_til_W
976 #4\xint_sub_bz
977 \W\XINT_sub_onestep #1#2{#7#6#5#4}{#3}%
978 }%

d'abord la branche principale #6 = 4 chiffres de N1, plus significatif en *pre-
mier*, #2#3#4#5 chiffres de N2, plus significatif en *dernier* On veut N2 - N1.

979 \def\XINT_sub_onestep #1#2#3#4#5#6%
980 {%
981 \expandafter\XINT_sub_backtoA\the\numexpr 11#5#4#3#2-#6+#1-\xint_c_i.%
982 }%

```

```

ON PRODUIT LE RÉSULTAT DANS LE BON ORDRE

983 \def\XINT_sub_backtoA #1#2#3.#4%
984 {%
985     \XINT_sub_A #2{#3#4}%
986 }%
987 \def\xint_sub_bz
988     \W\XINT_sub_onestep #1#2#3#4#5#6#7%
989 {%
990     \xint_UDzerofork
991     #1\XINT_sub_C    % une retenue
992     0\XINT_sub_D    % pas de retenue
993     \krof
994     {#7}#2#3#4#5%
995 }%
996 \def\XINT_sub_D #1#2\W\X\Y\Z
997 {%
998     \expandafter
999     \xint_cleanupzeros_andstop
1000     \romannumeral0%
1001     \XINT_rord_main {}#2%
1002     \xint_relax
1003     \xint_bye\xint_bye\xint_bye\xint_bye
1004     \xint_bye\xint_bye\xint_bye\xint_bye
1005     \xint_relax
1006     #1%
1007 }%
1008 \def\XINT_sub_C #1#2#3#4#5%
1009 {%
1010     \xint_gob_til_W
1011     #2\xint_sub_cz
1012     \W\XINT_sub_AC_onestep {#5#4#3#2}{#1}%
1013 }%
1014 \def\XINT_sub_AC_onestep #1%
1015 {%
1016     \expandafter\XINT_sub_backtoC\the\numexpr 11#1-\xint_c_i.%
1017 }%
1018 \def\XINT_sub_backtoC #1#2#3.#4%
1019 {%
1020     \XINT_sub_AC_checkcarry #2{#3#4}% la retenue va \^etre examin\'ee
1021 }%
1022 \def\XINT_sub_AC_checkcarry #1%
1023 {%
1024     \xint_gob_til_one #1\xint_sub_AC_nocarry 1\XINT_sub_C
1025 }%
1026 \def\xint_sub_AC_nocarry 1\XINT_sub_C #1#2\W\X\Y\Z
1027 {%
1028     \expandafter
1029     \XINT_cuz_loop

```

```

1030 \romannumeral0%
1031 \XINT_rord_main {}#2%
1032 \xint_relax
1033 \xint_bye\xint_bye\xint_bye\xint_bye
1034 \xint_bye\xint_bye\xint_bye\xint_bye
1035 \xint_relax
1036 #1\W\W\W\W\W\W\W\Z
1037 }%
1038 \def\xint_sub_cz\W\XINT_sub_AC_onestep #1%
1039 {%
1040 \XINT_cuz
1041 }%
1042 \def\xint_sub_az\W\XINT_sub_B #1#2#3#4#5#6#7%
1043 {%
1044 \xint_gob_til_W
1045 #4\xint_sub_ez
1046 \W\XINT_sub_Eenter #1{#3}#4#5#6#7%
1047 }%

le premier nombre continue, le résultat sera < 0.

1048 \def\XINT_sub_Eenter #1#2%
1049 {%
1050 \expandafter
1051 \XINT_sub_E\expandafter1\expandafter{\expandafter}%
1052 \romannumeral0%
1053 \XINT_rord_main {}#2%
1054 \xint_relax
1055 \xint_bye\xint_bye\xint_bye\xint_bye
1056 \xint_bye\xint_bye\xint_bye\xint_bye
1057 \xint_relax
1058 \W\X\Y\Z #1%
1059 }%
1060 \def\XINT_sub_E #1#2#3#4#5#6%
1061 {%
1062 \xint_gob_til_W #3\xint_sub_F\W
1063 \XINT_sub_Eonestep #1{#6#5#4#3}{#2}%
1064 }%
1065 \def\XINT_sub_Eonestep #1#2%
1066 {%
1067 \expandafter\XINT_sub_backtoE\the\numexpr 109999-#2+#1.%
1068 }%
1069 \def\XINT_sub_backtoE #1#2#3.#4%
1070 {%
1071 \XINT_sub_E #2{#3#4}%
1072 }%
1073 \def\xint_sub_F\W\XINT_sub_Eonestep #1#2#3#4%
1074 {%
1075 \xint_UDonezerofork
1076 #4#1{\XINT_sub_Fdec 0}% soustraire 1. Et faire signe -

```

### 36 Package *xint* implementation

```

1077      #1#4{\XINT_sub_Finc 1}% additionner 1. Et faire signe -
1078      10\XINT_sub_DD      % terminer. Mais avec signe -
1079      \krof
1080      {#3}%
1081 }%
1082 \def\XINT_sub_DD {\expandafter\xint_minus_thenstop\romannumeral0\XINT_sub_D }%
1083 \def\XINT_sub_Fdec #1#2#3#4#5#6%
1084 {%
1085     \xint_gob_til_W #3\xint_sub_Fdec_finish\W
1086     \XINT_sub_Fdec_onestep #1{#6#5#4#3}{#2}%
1087 }%
1088 \def\XINT_sub_Fdec_onestep #1#2%
1089 {%
1090     \expandafter\XINT_sub_backtoFdec\the\numexpr 11#2+#1-\xint_c_i.%
1091 }%
1092 \def\XINT_sub_backtoFdec #1#2#3.#4%
1093 {%
1094     \XINT_sub_Fdec #2{#3#4}%
1095 }%
1096 \def\xint_sub_Fdec_finish\W\XINT_sub_Fdec_onestep #1#2%
1097 {%
1098     \expandafter\xint_minus_thenstop\romannumeral0\XINT_cuz
1099 }%
1100 \def\XINT_sub_Finc #1#2#3#4#5#6%
1101 {%
1102     \xint_gob_til_W #3\xint_sub_Finc_finish\W
1103     \XINT_sub_Finc_onestep #1{#6#5#4#3}{#2}%
1104 }%
1105 \def\XINT_sub_Finc_onestep #1#2%
1106 {%
1107     \expandafter\XINT_sub_backtoFinc\the\numexpr 10#2+#1.%
1108 }%
1109 \def\XINT_sub_backtoFinc #1#2#3.#4%
1110 {%
1111     \XINT_sub_Finc #2{#3#4}%
1112 }%
1113 \def\xint_sub_Finc_finish\W\XINT_sub_Finc_onestep #1#2#3%
1114 {%
1115     \xint_UDzerofork
1116     #1{\expandafter\expandafter\expandafter
1117         \xint_minus_thenstop\xint_cleanupzeros_nostop}%
1118     0{ -1}%
1119     \krof
1120     #3%
1121 }%
1122 \def\xint_sub_ez\W\XINT_sub_Eenter #1%
1123 {%
1124     \xint_UDzerofork
1125     #1\XINT_sub_K % il y a une retenue

```

### 36 Package *xint* implementation

```
1126      0\XINT_sub_L % pas de retenue
1127      \krof
1128 }%
1129 \def\XINT_sub_L #1\W\X\Y\Z {\XINT_cuz_loop #1\W\W\W\W\W\W\W\Z }%
1130 \def\XINT_sub_K #1%
1131 {%
1132      \expandafter
1133      \XINT_sub_KK\expandafter1\expandafter{\expandafter}%
1134      \romannumeral0%
1135      \XINT_rord_main {}#1%
1136      \xint_relax
1137      \xint_bye\xint_bye\xint_bye\xint_bye
1138      \xint_bye\xint_bye\xint_bye\xint_bye
1139      \xint_relax
1140 }%
1141 \def\XINT_sub_KK #1#2#3#4#5#6%
1142 {%
1143      \xint_gob_til_W #3\xint_sub_KK_finish\W
1144      \XINT_sub_KK_onestep #1{#6#5#4#3}{#2}%
1145 }%
1146 \def\XINT_sub_KK_onestep #1#2%
1147 {%
1148      \expandafter\XINT_sub_backtoKK\the\numexpr 109999-#2+#1.%
1149 }%
1150 \def\XINT_sub_backtoKK #1#2#3.#4%
1151 {%
1152      \XINT_sub_KK #2{#3#4}%
1153 }%
1154 \def\xint_sub_KK_finish\W\XINT_sub_KK_onestep #1#2#3%
1155 {%
1156      \expandafter\xint_minus_thenstop
1157      \romannumeral0\XINT_cuz_loop #3\W\W\W\W\W\W\W\Z
1158 }%
```

#### 36.29 \xintCmp

Release 1.09a has \xintnum inserted into \xintCmp. Unnecessary \xintiCmp suppressed in 1.09f.

```
1159 \def\xintCmp {\romannumeral0\xintcmp }%
1160 \def\xintcmp #1%
1161 {%
1162      \expandafter\xint_cmp\expandafter{\romannumeral0\xintnum{#1}}%
1163 }%
1164 \def\xint_cmp #1#2%
1165 {%
1166      \expandafter\XINT_cmp_fork \romannumeral0\xintnum{#2}\Z #1\Z
1167 }%
1168 \def\XINT_Cmp #1#2{\romannumeral0\XINT_cmp_fork #2\Z #1\Z }%
```

```

COMPARAISON
1 si #3#4>#1#2, 0 si #3#4=#1#2, -1 si #3#4<#1#2
#3#4 vient du *premier*, #1#2 vient du *second*

1169 \def\XINT_cmp_fork #1#2\Z #3#4\Z
1170 {%
1171   \xint_UDsignsfork
1172     #1#3\XINT_cmp_minusminus
1173     #1-\XINT_cmp_minusplus
1174     #3-\XINT_cmp_plusminus
1175     --{\xint_UDzerosfork
1176       #1#3\XINT_cmp_zerozero
1177       #10\XINT_cmp_zeroplus
1178       #30\XINT_cmp_pluszero
1179       00\XINT_cmp_plusplus
1180     \krof }%
1181   \krof
1182   {#2}{#4}#1#3%
1183 }%
1184 \def\XINT_cmp_minusplus #1#2#3#4{ 1}%
1185 \def\XINT_cmp_plusminus #1#2#3#4{ -1}%
1186 \def\XINT_cmp_zerozero #1#2#3#4{ 0}%
1187 \def\XINT_cmp_zeroplus #1#2#3#4{ 1}%
1188 \def\XINT_cmp_pluszero #1#2#3#4{ -1}%
1189 \def\XINT_cmp_plusplus #1#2#3#4%
1190 {%
1191   \XINT_cmp_pre {#4#2}{#3#1}%
1192 }%
1193 \def\XINT_cmp_minusminus #1#2#3#4%
1194 {%
1195   \XINT_cmp_pre {#1}{#2}%
1196 }%
1197 \def\XINT_cmp_pre #1%
1198 {%
1199   \expandafter\XINT_cmp_pre_b\expandafter
1200   {\romannumeral0\XINT_RQ {#1\R\R\R\R\R\R\R\R\Z }%
1201 }%
1202 \def\XINT_cmp_pre_b #1#2%
1203 {%
1204   \expandafter\XINT_cmp_A
1205   \expandafter1\expandafter{\expandafter}%
1206   \romannumeral0\XINT_RQ {#2\R\R\R\R\R\R\R\R\Z
1207   \W\X\Y\Z #1\W\X\Y\Z
1208 }%

```

## COMPARAISON

N1 et N2 sont présentés à l'envers ET ON A RAJOUTÉ DES ZÉROS POUR QUE LEUR LONGUEURS À CHACUN SOIENT MULTIPLES DE 4, MAIS AUCUN NE SE TERMINE EN 0000. routine appelée via

### 36 Package *xint* implementation

```

\XINT_cmp_A 1{>N1>\W\X\Y\Z<N2>\W\X\Y\Z
ATTENTION RENVOIE 1 SI N1 < N2, 0 si N1 = N2, -1 si N1 > N2

1209 \def\XINT_cmp_A #1#2#3\W\X\Y\Z #4#5#6#7%
1210 {%
1211     \xint_gob_til_W #4\xint_cmp_az\W
1212     \XINT_cmp_B #1{#4#5#6#7}{#2}#3\W\X\Y\Z
1213 }%
1214 \def\XINT_cmp_B #1#2#3#4#5#6#7%
1215 {%
1216     \xint_gob_til_W#4\xint_cmp_bz\W
1217     \XINT_cmp_onestep #1#2{#7#6#5#4}{#3}%
1218 }%
1219 \def\XINT_cmp_onestep #1#2#3#4#5#6%
1220 {%
1221     \expandafter\XINT_cmp_backtoA\the\numexpr 11#5#4#3#2-#6+#1-\xint_c_i.%
1222 }%
1223 \def\XINT_cmp_backtoA #1#2#3.#4%
1224 {%
1225     \XINT_cmp_A #2{#3#4}%
1226 }%
1227 \def\xint_cmp_bz\W\XINT_cmp_onestep #1\Z { 1}%
1228 \def\xint_cmp_az\W\XINT_cmp_B #1#2#3#4#5#6#7%
1229 {%
1230     \xint_gob_til_W #4\xint_cmp_ez\W
1231     \XINT_cmp_Enter #1{#3}#4#5#6#7%
1232 }%
1233 \def\XINT_cmp_Enter #1\Z { -1}%
1234 \def\xint_cmp_ez\W\XINT_cmp_Enter #1%
1235 {%
1236     \xint_UDzerofork
1237     #1\XINT_cmp_K                %    il y a une retenue
1238     0\XINT_cmp_L                %    pas de retenue
1239     \krof
1240 }%
1241 \def\XINT_cmp_K #1\Z { -1}%
1242 \def\XINT_cmp_L #1{\XINT_OneIfPositive_main #1}%
1243 \def\XINT_OneIfPositive #1%
1244 {%
1245     \XINT_OneIfPositive_main #1\W\X\Y\Z%
1246 }%
1247 \def\XINT_OneIfPositive_main #1#2#3#4%
1248 {%
1249     \xint_gob_til_Z #4\xint_OneIfPositive_terminated\Z
1250     \XINT_OneIfPositive_onestep #1#2#3#4%
1251 }%
1252 \def\xint_OneIfPositive_terminated\Z\XINT_OneIfPositive_onestep\W\X\Y\Z { 0}%
1253 \def\XINT_OneIfPositive_onestep #1#2#3#4%
1254 {%

```

```

1255 \expandafter\XINT_OneIfPositive_check\the\numexpr #1#2#3#4\relax
1256 }%
1257 \def\XINT_OneIfPositive_check #1%
1258 {%
1259 \xint_gob_til_zero #1\xint_OneIfPositive_backtomain 0%
1260 \XINT_OneIfPositive_finish #1%
1261 }%
1262 \def\XINT_OneIfPositive_finish #1\W\X\Y\Z{ 1}%
1263 \def\xint_OneIfPositive_backtomain 0\XINT_OneIfPositive_finish 0%
1264 {\XINT_OneIfPositive_main }%

```

### 36.30 \xintEq, \xintGt, \xintLt

1.09a.

```

1265 \def\xintEq {\romannumeral0\xinteq }%
1266 \def\xinteq #1#2{\xintifeq{#1}{#2}{1}{0}}%
1267 \def\xintGt {\romannumeral0\xintgt }%
1268 \def\xintgt #1#2{\xintifgt{#1}{#2}{1}{0}}%
1269 \def\xintLt {\romannumeral0\xintlt }%
1270 \def\xintlt #1#2{\xintiflt{#1}{#2}{1}{0}}%

```

### 36.31 \xintIsZero, \xintIsNotZero

1.09a. restyled in 1.09i.

```

1271 \def\xintIsZero {\romannumeral0\xintiszero }%
1272 \def\xintiszero #1{\if0\xintSgn{#1}\xint_afterfi{ 1}\else\xint_afterfi{ 0}\fi}%
1273 \def\xintIsNotZero {\romannumeral0\xintisnotzero }%
1274 \def\xintisnotzero
1275 #1{\if0\xintSgn{#1}\xint_afterfi{ 0}\else\xint_afterfi{ 1}\fi}%

```

### 36.32 \xintIsTrue, \xintNot, \xintIsFalse

1.09c

```

1276 \let\xintIsTrue\xintIsNotZero
1277 \let\xintNot\xintIsZero
1278 \let\xintIsFalse\xintIsZero

```

### 36.33 \xintAND, \xintOR, \xintXOR

1.09a. Embarrasing bugs in \xintAND and \xintOR which inserted a space token corrected in 1.09i. \xintxor restyled with \if (faster) in 1.09i

```

1279 \def\xintAND {\romannumeral0\xintand }%
1280 \def\xintand #1#2{\if0\xintSgn{#1}\expandafter\xint_firstoftwo
1281 \else\expandafter\xint_secondoftwo\fi

```

```

1282          { 0}{\xintisnotzero{#2}}}%
1283 \def\xintOR {\romannumeral0\xintor }%
1284 \def\xintor #1#2{\if0\xintSgn{#1}\expandafter\xint_firstoftwo
1285               \else\expandafter\xint_secondoftwo\fi
1286               {\xintisnotzero{#2}}{ 1}}%
1287 \def\xintXOR {\romannumeral0\xintxor }%
1288 \def\xintxor #1#2{\if\xintIsZero{#1}\xintIsZero{#2}%
1289               \xint_afterfi{ 0}\else\xint_afterfi{ 1}\fi }%

```

### 36.34 \xintANDof

New with 1.09a. \xintANDof works also with an empty list.

```

1290 \def\xintANDof {\romannumeral0\xintandof }%
1291 \def\xintandof #1{\expandafter\XINT_andof_a\romannumeral-‘0#1\relax }%
1292 \def\XINT_andof_a #1{\expandafter\XINT_andof_b\romannumeral-‘0#1\Z }%
1293 \def\XINT_andof_b #1%
1294       {\xint_gob_til_relax #1\XINT_andof_e\relax\XINT_andof_c #1}%
1295 \def\XINT_andof_c #1\Z
1296       {\xintifTrueAelseB {#1}{\XINT_andof_a}{\XINT_andof_no}}%
1297 \def\XINT_andof_no #1\relax { 0}%
1298 \def\XINT_andof_e #1\Z { 1}%

```

### 36.35 \xintORof

New with 1.09a. Works also with an empty list.

```

1299 \def\xintORof {\romannumeral0\xintorof }%
1300 \def\xintorof #1{\expandafter\XINT_orof_a\romannumeral-‘0#1\relax }%
1301 \def\XINT_orof_a #1{\expandafter\XINT_orof_b\romannumeral-‘0#1\Z }%
1302 \def\XINT_orof_b #1%
1303       {\xint_gob_til_relax #1\XINT_orof_e\relax\XINT_orof_c #1}%
1304 \def\XINT_orof_c #1\Z
1305       {\xintifTrueAelseB {#1}{\XINT_orof_yes}{\XINT_orof_a}}%
1306 \def\XINT_orof_yes #1\relax { 1}%
1307 \def\XINT_orof_e #1\Z { 0}%

```

### 36.36 \xintXORof

New with 1.09a. Works with an empty list, too. \XINT\_xorof\_c more efficient in 1.09i

```

1308 \def\xintXORof {\romannumeral0\xintxorof }%
1309 \def\xintxorof #1{\expandafter\XINT_xorof_a\expandafter
1310       0\romannumeral-‘0#1\relax }%
1311 \def\XINT_xorof_a #1#2{\expandafter\XINT_xorof_b\romannumeral-‘0#2\Z #1}%
1312 \def\XINT_xorof_b #1%
1313       {\xint_gob_til_relax #1\XINT_xorof_e\relax\XINT_xorof_c #1}%

```

```

1314 \def\XINT_xorof_c #1\Z #2%
1315     {\xintifTrueAelseB {#1}{\if #20\xint_afterfi{\XINT_xorof_a 1}%
1316         \else\xint_afterfi{\XINT_xorof_a 0}\fi}%
1317     {\XINT_xorof_a #2}%
1318     }%
1319 \def\XINT_xorof_e #1\Z #2{ #2}%

```

### 36.37 \xintGeq

Release 1.09a has \xintnum added into \xintGeq. Unused and useless \xintiGeq removed in 1.09e. PLUS GRAND OU ÉGAL attention compare les **\*\*valeurs absolues\*\***

```

1320 \def\xintGeq {\romannumeral0\xintgeq }%
1321 \def\xintgeq #1%
1322 {%
1323     \expandafter\xint_geq\expandafter {\romannumeral0\xintnum{#1}}%
1324 }%
1325 \def\xint_geq #1#2%
1326 {%
1327     \expandafter\XINT_geq_fork \romannumeral0\xintnum{#2}\Z #1\Z
1328 }%
1329 \def\XINT_Geq #1#2{\romannumeral0\XINT_geq_fork #2\Z #1\Z }%

```

PLUS GRAND OU ÉGAL ATTENTION, TESTE les VALEURS ABSOLUES

```

1330 \def\XINT_geq_fork #1#2\Z #3#4\Z
1331 {%
1332     \xint_UDzerofork
1333     #1\XINT_geq_secondiszero % |#1#2|=0
1334     #3\XINT_geq_firstiszero % |#1#2|>0
1335     0{\xint_UDsignsfork
1336         #1#3\XINT_geq_minusminus
1337         #1-\XINT_geq_minusplus
1338         #3-\XINT_geq_plusminus
1339         --\XINT_geq_plusplus
1340     \krof }%
1341     \krof
1342     {#2}{#4}#1#3%
1343 }%
1344 \def\XINT_geq_secondiszero #1#2#3#4{ 1}%
1345 \def\XINT_geq_firstiszero #1#2#3#4{ 0}%
1346 \def\XINT_geq_plusplus #1#2#3#4{\XINT_geq_pre {#4#2}{#3#1}}%
1347 \def\XINT_geq_minusminus #1#2#3#4{\XINT_geq_pre {#2}{#1}}%
1348 \def\XINT_geq_minusplus #1#2#3#4{\XINT_geq_pre {#4#2}{#1}}%
1349 \def\XINT_geq_plusminus #1#2#3#4{\XINT_geq_pre {#2}{#3#1}}%
1350 \def\XINT_geq_pre #1%
1351 {%
1352     \expandafter\XINT_geq_pre_b\expandafter
1353     {\romannumeral0\XINT_RQ {}#1\R\R\R\R\R\R\R\R\Z }%

```

```

1354 }%
1355 \def\XINT_geq_pre_b #1#2%
1356 {%
1357   \expandafter\XINT_geq_A
1358   \expandafter1\expandafter{\expandafter}%
1359   \romannumeral0\XINT_RQ {}#2\R\R\R\R\R\R\R\R\Z
1360   \W\X\Y\Z #1 \W\X\Y\Z
1361 }%

PLUS GRAND OU ÉGAL
N1 et N2 sont présentés à l'envers ET ON A RAJOUTÉ DES ZÉROS POUR QUE LEURS
LONGUEURS À CHACUN SOIENT MULTIPLES DE 4, MAIS AUCUN NE SE TERMINE EN 0000
routine appelée via
\romannumeral0\XINT_geq_A 1{<N1>\W\X\Y\Z<N2>\W\X\Y\Z
ATTENTION RENVOIE 1 SI N1 < N2 ou N1 = N2 et 0 si N1 > N2

1362 \def\XINT_geq_A #1#2#3\W\X\Y\Z #4#5#6#7%
1363 {%
1364   \xint_gob_til_W #4\xint_geq_az\W
1365   \XINT_geq_B #1{#4#5#6#7}{#2}#3\W\X\Y\Z
1366 }%
1367 \def\XINT_geq_B #1#2#3#4#5#6#7%
1368 {%
1369   \xint_gob_til_W #4\xint_geq_bz\W
1370   \XINT_geq_onestep #1#2{#7#6#5#4}{#3}%
1371 }%
1372 \def\XINT_geq_onestep #1#2#3#4#5#6%
1373 {%
1374   \expandafter\XINT_geq_backtoA\the\numexpr 11#5#4#3#2-#6+#1-\xint_c.i.%
1375 }%
1376 \def\XINT_geq_backtoA #1#2#3.#4%
1377 {%
1378   \XINT_geq_A #2{#3#4}%
1379 }%
1380 \def\xint_geq_bz\W\XINT_geq_onestep #1\W\X\Y\Z { 1}%
1381 \def\xint_geq_az\W\XINT_geq_B #1#2#3#4#5#6#7%
1382 {%
1383   \xint_gob_til_W #4\xint_geq_ez\W
1384   \XINT_geq_Eenter #1%
1385 }%
1386 \def\XINT_geq_Eenter #1\W\X\Y\Z { 0}%
1387 \def\xint_geq_ez\W\XINT_geq_Eenter #1%
1388 {%
1389   \xint_UDzerofork
1390   #1{ 0}          %      il y a une retenue
1391   0{ 1}          %      pas de retenue
1392   \krof
1393 }%

```

**36.38 \xintMax**

The rationale is that it is more efficient than using `\xintCmp`. 1.03 makes the code a tiny bit slower but easier to re-use for fractions. Note: actually since 1.08a code for fractions does not all reduce to these entry points, so perhaps I should revert the changes made in 1.03. Release 1.09a has `\xintnum` added into `\xintiMax`.

```

1394 \def\xintiMax {\romannumeral0\xintimax}%
1395 \def\xintimax #1%
1396 {%
1397   \expandafter\xint_max\expandafter {\romannumeral0\xintnum{#1}}%
1398 }%
1399 \let\xintMax\xintiMax \let\xintmax\xintimax
1400 \def\xint_max #1#2%
1401 {%
1402   \expandafter\XINT_max_pre\expandafter {\romannumeral0\xintnum{#2}}{#1}%
1403 }%
1404 \def\XINT_max_pre #1#2{\XINT_max_fork #1\Z #2\Z {#2}{#1}}%
1405 \def\XINT_Max #1#2{\romannumeral0\XINT_max_fork #2\Z #1\Z {#1}{#2}}%

#3#4 vient du *premier*, #1#2 vient du *second*

1406 \def\XINT_max_fork #1#2\Z #3#4\Z
1407 {%
1408   \xint_UDsignsfork
1409     #1#3\XINT_max_minusminus % A < 0, B < 0
1410     #1-\XINT_max_minusplus % B < 0, A >= 0
1411     #3-\XINT_max_plusminus % A < 0, B >= 0
1412     --{\xint_UDzerosfork
1413       #1#3\XINT_max_zerozero % A = B = 0
1414       #10\XINT_max_zeroplus % B = 0, A > 0
1415       #30\XINT_max_pluszero % A = 0, B > 0
1416       00\XINT_max_plusplus % A, B > 0
1417     \krof}%
1418   \krof
1419   {#2}{#4}#1#3%
1420 }%

A = #4#2, B = #3#1

1421 \def\XINT_max_zerozero #1#2#3#4{\xint_firstoftwo_thenstop}%
1422 \def\XINT_max_zeroplus #1#2#3#4{\xint_firstoftwo_thenstop}%
1423 \def\XINT_max_pluszero #1#2#3#4{\xint_secondoftwo_thenstop}%
1424 \def\XINT_max_minusplus #1#2#3#4{\xint_firstoftwo_thenstop}%
1425 \def\XINT_max_plusminus #1#2#3#4{\xint_secondoftwo_thenstop}%
1426 \def\XINT_max_plusplus #1#2#3#4%
1427 {%
1428   \ifodd\XINT_Geq {#4#2}{#3#1}
1429     \expandafter\xint_firstoftwo_thenstop

```

```

1430 \else
1431 \expandafter\xint_secondoftwo_thenstop
1432 \fi
1433 }%

```

#3=-, #4=-, #1 = |B| = -B, #2 = |A| = -A

```

1434 \def\xINT_max_minusminus #1#2#3#4%
1435 {%
1436 \ifodd\xINT_Geq {#1}{#2}
1437 \expandafter\xint_firstoftwo_thenstop
1438 \else
1439 \expandafter\xint_secondoftwo_thenstop
1440 \fi
1441 }%

```

### 36.39 \xintMaxof

New with 1.09a.

```

1442 \def\xintiMaxof {\romannumeral0\xintimaxof }%
1443 \def\xintimaxof #1{\expandafter\xINT_imaxof_a\romannumeral-‘0#1\relax }%
1444 \def\xINT_imaxof_a #1{\expandafter\xINT_imaxof_b\romannumeral0\xintnum{#1}\Z }%
1445 \def\xINT_imaxof_b #1\Z #2%
1446 {\expandafter\xINT_imaxof_c\romannumeral-‘0#2\Z {#1}\Z}%
1447 \def\xINT_imaxof_c #1%
1448 {\xint_gob_til_relax #1\xINT_imaxof_e\relax\xINT_imaxof_d #1}%
1449 \def\xINT_imaxof_d #1\Z
1450 {\expandafter\xINT_imaxof_b\romannumeral0\xintimax {#1}}%
1451 \def\xINT_imaxof_e #1\Z #2\Z { #2}%
1452 \let\xintMaxof\xintiMaxof \let\xintmaxof\xintimaxof

```

### 36.40 \xintMin

\xintnum added New with 1.09a.

```

1453 \def\xintiMin {\romannumeral0\xintimin }%
1454 \def\xintimin #1%
1455 {%
1456 \expandafter\xint_min\expandafter {\romannumeral0\xintnum{#1}}%
1457 }%
1458 \let\xintMin\xintiMin \let\xintmin\xintimin
1459 \def\xint_min #1#2%
1460 {%
1461 \expandafter\xINT_min_pre\expandafter {\romannumeral0\xintnum{#2}}{#1}%
1462 }%
1463 \def\xINT_min_pre #1#2{\xINT_min_fork #1\Z #2\Z {#2}{#1}}%
1464 \def\xINT_Min #1#2{\romannumeral0\xINT_min_fork #2\Z #1\Z {#1}{#2}}%

```

```

#3#4 vient du *premier*, #1#2 vient du *second*

1465 \def\XINT_min_fork #1#2\Z #3#4\Z
1466 {%
1467   \xint_UDsignsfork
1468     #1#3\XINT_min_minusminus % A < 0, B < 0
1469     #1-\XINT_min_minusplus % B < 0, A >= 0
1470     #3-\XINT_min_plusminus % A < 0, B >= 0
1471     --{\xint_UDzerosfork
1472       #1#3\XINT_min_zerozero % A = B = 0
1473       #10\XINT_min_zeroplus % B = 0, A > 0
1474       #30\XINT_min_pluszero % A = 0, B > 0
1475       00\XINT_min_plusplus % A, B > 0
1476     \krof }%
1477   \krof
1478   {#2}{#4}#1#3%
1479 }%

A = #4#2, B = #3#1

1480 \def\XINT_min_zerozero #1#2#3#4{\xint_firstoftwo_thenstop }%
1481 \def\XINT_min_zeroplus #1#2#3#4{\xint_secondoftwo_thenstop }%
1482 \def\XINT_min_pluszero #1#2#3#4{\xint_firstoftwo_thenstop }%
1483 \def\XINT_min_minusplus #1#2#3#4{\xint_secondoftwo_thenstop }%
1484 \def\XINT_min_plusminus #1#2#3#4{\xint_firstoftwo_thenstop }%
1485 \def\XINT_min_plusplus #1#2#3#4%
1486 {%
1487   \ifodd\XINT_Geq {#4#2}{#3#1}
1488     \expandafter\xint_secondoftwo_thenstop
1489   \else
1490     \expandafter\xint_firstoftwo_thenstop
1491   \fi
1492 }%

#3=-, #4=-, #1 = |B| = -B, #2 = |A| = -A

1493 \def\XINT_min_minusminus #1#2#3#4%
1494 {%
1495   \ifodd\XINT_Geq {#1}{#2}
1496     \expandafter\xint_secondoftwo_thenstop
1497   \else
1498     \expandafter\xint_firstoftwo_thenstop
1499   \fi
1500 }%

```

### 36.41 \xintMinof

1.09a

```

1501 \def\xintiMinof      {\romannumeral0\xintiminof }%
1502 \def\xintiminof      #1{\expandafter\XINT_iminof_a\romannumeral-‘0#1\relax }%
1503 \def\XINT_iminof_a    #1{\expandafter\XINT_iminof_b\romannumeral0\xintnum{#1}\Z }%
1504 \def\XINT_iminof_b    #1\Z #2%
1505      {\expandafter\XINT_iminof_c\romannumeral-‘0#2\Z {#1}\Z}%
1506 \def\XINT_iminof_c    #1%
1507      {\xint_gob_til_relax #1\XINT_iminof_e\relax\XINT_iminof_d #1}%
1508 \def\XINT_iminof_d    #1\Z
1509      {\expandafter\XINT_iminof_b\romannumeral0\xintimin {#1}}%
1510 \def\XINT_iminof_e    #1\Z #2\Z { #2}%
1511 \let\xintMinof\xintiMinof \let\xintminof\xintiminof

```

### 36.42 \xintSum

\xintSum {{a}{b}}...{z}}

\xintSumExpr {a}{b}...{z}\relax

1.03 (drastically) simplifies and makes the routines more efficient (for big computations). Also the way \xintSum and \xintSumExpr ...\relax are related, has been modified. Now \xintSumExpr \z \relax is accepted input when \z expands to a list of braced terms (prior only \xintSum {z} or \xintSum \z was possible).

1.09a does NOT add the \xintnum overhead. 1.09h renames \xintiSum to \xintiiSum to correctly reflect this.

```

1512 \def\xintiiSum {\romannumeral0\xintiisum }%
1513 \def\xintiisum #1{\xintiisumexpr #1\relax }%
1514 \def\xintiiSumExpr {\romannumeral0\xintiisumexpr }%
1515 \def\xintiisumexpr {\expandafter\XINT_sumexpr\romannumeral-‘0}%
1516 \let\xintSum\xintiiSum \let\xintsum\xintiisum
1517 \let\xintSumExpr\xintiiSumExpr \let\xintsumexpr\xintiisumexpr
1518 \def\XINT_sumexpr {\XINT_sum_loop {0000}{0000}}%
1519 \def\XINT_sum_loop #1#2#3%
1520 {%
1521     \expandafter\XINT_sum_checksign\romannumeral-‘0#3\Z {#1}{#2}%
1522 }%
1523 \def\XINT_sum_checksign #1%
1524 {%
1525     \xint_gob_til_relax #1\XINT_sum_finished\relax
1526     \xint_gob_til_zero #1\XINT_sum_skipzeroinput0%
1527     \xint_UDsignfork
1528     #1\XINT_sum_N
1529     -{\XINT_sum_P #1}%
1530     \krof
1531 }%
1532 \def\XINT_sum_finished #1\Z #2#3%
1533 {%
1534     \XINT_sub_A 1{#3}\W\X\Y\Z #2\W\X\Y\Z
1535 }%
1536 \def\XINT_sum_skipzeroinput #1\krof #2\Z {\XINT_sum_loop }%
1537 \def\XINT_sum_P #1\Z #2%

```

```

1538 {%
1539   \expandafter\XINT_sum_loop\expandafter
1540   {\romannumeral0\expandafter
1541    \XINT_addr_A\expandafter0\expandafter{\expandafter}%
1542    \romannumeral0\XINT_RQ {}#1\R\R\R\R\R\R\R\R\Z
1543    \W\X\Y\Z #2\W\X\Y\Z }%
1544 }%
1545 \def\XINT_sum_N #1\Z #2#3%
1546 {%
1547   \expandafter\XINT_sum_NN\expandafter
1548   {\romannumeral0\expandafter
1549    \XINT_addr_A\expandafter0\expandafter{\expandafter}%
1550    \romannumeral0\XINT_RQ {}#1\R\R\R\R\R\R\R\R\Z
1551    \W\X\Y\Z #3\W\X\Y\Z }{#2}%
1552 }%
1553 \def\XINT_sum_NN #1#2{\XINT_sum_loop {#2}{#1}}%

```

### 36.43 \xintMul

1.09a adds \xintnum

```

1554 \def\xintiMul {\romannumeral0\xintiimul }%
1555 \def\xintiimul #1%
1556 {%
1557   \expandafter\xint_iimul\expandafter {\romannumeral-‘0#1}%
1558 }%
1559 \def\xint_iimul #1#2%
1560 {%
1561   \expandafter\XINT_mul_fork \romannumeral-‘0#2\Z #1\Z
1562 }%
1563 \def\xintiMul {\romannumeral0\xintimul }%
1564 \def\xintimul #1%
1565 {%
1566   \expandafter\xint_mul\expandafter {\romannumeral0\xintnum{#1}}%
1567 }%
1568 \def\xint_mul #1#2%
1569 {%
1570   \expandafter\XINT_mul_fork \romannumeral0\xintnum{#2}\Z #1\Z
1571 }%
1572 \let\xintMul\xintiMul \let\xintmul\xintimul
1573 \def\XINT_Mul #1#2{\romannumeral0\XINT_mul_fork #2\Z #1\Z }%

```

#### MULTIPLICATION

Ici #1#2 = 2e input et #3#4 = 1er input

Release 1.03 adds some overhead to first compute and compare the lengths of the two inputs. The algorithm is asymmetrical and whether the first input is the longest or the shortest sometimes has a strong impact. 50 digits times 1000 digits used to be 5 times faster than 1000 digits times 50 digits. With the new code, the user input order does not matter as it is decided by the routine what is best. This is

important for the extension to fractions, as there is no way then to generally control or guess the most frequent sizes of the inputs besides actually computing their lengths.

```

1574 \def\XINT_mul_fork #1#2\Z #3#4\Z
1575 {%
1576   \xint_UDzerofork
1577   #1\XINT_mul_zero
1578   #3\XINT_mul_zero
1579   0{\xint_UDsignsfork
1580     #1#3\XINT_mul_minusminus          % #1 = #3 = -
1581     #1-{\XINT_mul_minusplus #3}%      % #1 = -
1582     #3-{\XINT_mul_plusminus #1}%      % #3 = -
1583     --{\XINT_mul_plusplus #1#3}%
1584     \krof }%
1585   \krof
1586   {#2}{#4}%
1587 }%
1588 \def\XINT_mul_zero #1#2{ 0}%
1589 \def\XINT_mul_minusminus #1#2%
1590 {%
1591   \expandafter\XINT_mul_choice_a
1592   \expandafter{\romannumeral0\xintlength {#2}}%
1593   {\romannumeral0\xintlength {#1}}{#1}{#2}%
1594 }%
1595 \def\XINT_mul_minusplus #1#2#3%
1596 {%
1597   \expandafter\xint_minus_thenstop\romannumeral0\expandafter
1598   \XINT_mul_choice_a
1599   \expandafter{\romannumeral0\xintlength {#1#3}}%
1600   {\romannumeral0\xintlength {#2}}{#2}{#1#3}%
1601 }%
1602 \def\XINT_mul_plusminus #1#2#3%
1603 {%
1604   \expandafter\xint_minus_thenstop\romannumeral0\expandafter
1605   \XINT_mul_choice_a
1606   \expandafter{\romannumeral0\xintlength {#3}}%
1607   {\romannumeral0\xintlength {#1#2}}{#1#2}{#3}%
1608 }%
1609 \def\XINT_mul_plusplus #1#2#3#4%
1610 {%
1611   \expandafter\XINT_mul_choice_a
1612   \expandafter{\romannumeral0\xintlength {#2#4}}%
1613   {\romannumeral0\xintlength {#1#3}}{#1#3}{#2#4}%
1614 }%
1615 \def\XINT_mul_choice_a #1#2%
1616 {%
1617   \expandafter\XINT_mul_choice_b\expandafter{#2}{#1}%
1618 }%

```

```

1619 \def\XINT_mul_choice_b #1#2%
1620 {%
1621   \ifnum #1<\xint_c_v
1622     \expandafter\XINT_mul_choice_littlebyfirst
1623   \else
1624     \ifnum #2<\xint_c_v
1625       \expandafter\expandafter\expandafter\XINT_mul_choice_littlebysecond
1626     \else
1627       \expandafter\expandafter\expandafter\XINT_mul_choice_compare
1628     \fi
1629   \fi
1630   {#1}{#2}%
1631 }%
1632 \def\XINT_mul_choice_littlebyfirst #1#2#3#4%
1633 {%
1634   \expandafter\XINT_mul_M
1635   \expandafter{\the\numexpr #3\expandafter}%
1636   \romannumeral0\XINT_RQ {}#4\R\R\R\R\R\R\R\R\Z \Z\Z\Z\Z
1637 }%
1638 \def\XINT_mul_choice_littlebysecond #1#2#3#4%
1639 {%
1640   \expandafter\XINT_mul_M
1641   \expandafter{\the\numexpr #4\expandafter}%
1642   \romannumeral0\XINT_RQ {}#3\R\R\R\R\R\R\R\R\Z \Z\Z\Z\Z
1643 }%
1644 \def\XINT_mul_choice_compare #1#2%
1645 {%
1646   \ifnum #1>#2
1647     \expandafter \XINT_mul_choice_i
1648   \else
1649     \expandafter \XINT_mul_choice_ii
1650   \fi
1651   {#1}{#2}%
1652 }%
1653 \def\XINT_mul_choice_i #1#2%
1654 {%
1655   \ifnum #1<\numexpr\ifcase \numexpr (#2-\xint_c_iii)/\xint_c_iv\relax
1656     \or 330\or 168\or 109\or 80\or 66\or 52\else 0\fi\relax
1657     \expandafter\XINT_mul_choice_same
1658   \else
1659     \expandafter\XINT_mul_choice_permute
1660   \fi
1661 }%
1662 \def\XINT_mul_choice_ii #1#2%
1663 {%
1664   \ifnum #2<\numexpr\ifcase \numexpr (#1-\xint_c_iii)/\xint_c_iv\relax
1665     \or 330\or 168\or 109\or 80\or 66\or 52\else 0\fi\relax
1666     \expandafter\XINT_mul_choice_permute
1667   \else

```

```

1668 \expandafter\XINT_mul_choice_same
1669 \fi
1670 }%
1671 \def\XINT_mul_choice_same #1#2%
1672 {%
1673 \expandafter\XINT_mul_enter
1674 \romannumeral0\XINT_RQ {}#1\R\R\R\R\R\R\R\R\Z
1675 \Z\Z\Z\Z #2\W\W\W\W
1676 }%
1677 \def\XINT_mul_choice_permute #1#2%
1678 {%
1679 \expandafter\XINT_mul_enter
1680 \romannumeral0\XINT_RQ {}#2\R\R\R\R\R\R\R\R\Z
1681 \Z\Z\Z\Z #1\W\W\W\W
1682 }%

```

Cette portion de routine d'addition se branche directement sur `_addr_` lorsque le premier nombre est épuisé, ce qui est garanti arriver avant le second nombre. Elle produit son résultat toujours sur 4n, renversé. Ses deux inputs sont garantis sur 4n.

```

1683 \def\XINT_mul_Ar #1#2#3#4#5#6%
1684 {%
1685 \xint_gob_til_Z #6\xint_mul_br\Z\XINT_mul_Br #1{#6#5#4#3}{#2}%
1686 }%
1687 \def\xint_mul_br\Z\XINT_mul_Br #1#2%
1688 {%
1689 \XINT_addr_AC_checkcarry #1%
1690 }%
1691 \def\XINT_mul_Br #1#2#3#4\W\X\Y\Z #5#6#7#8%
1692 {%
1693 \expandafter\XINT_mul_ABEAr
1694 \the\numexpr #1+10#2+#8#7#6#5.{#3}#4\W\X\Y\Z
1695 }%
1696 \def\XINT_mul_ABEAr #1#2#3#4#5#6.#7%
1697 {%
1698 \XINT_mul_Ar #2{#7#6#5#4#3}%
1699 }%

```

<< Petite >> multiplication. `mul_Mr` renvoie le résultat \*à l'envers\*, sur \*4n\*  
`\romannumeral0\XINT_mul_Mr {<n>}<N>\Z\Z\Z\Z`  
Fait la multiplication de <N> par <n>, qui est < 10000. <N> est présenté \*à l'envers\*, sur \*4n\*. Lorsque <n> vaut 0, donne 0000.

```

1700 \def\XINT_mul_Mr #1%
1701 {%
1702 \expandafter\XINT_mul_Mr_checkifzeroorone\expandafter{\the\numexpr #1}%
1703 }%
1704 \def\XINT_mul_Mr_checkifzeroorone #1%
1705 {%

```

```

1706 \ifcase #1
1707 \expandafter\XINT_mul_Mr_zero
1708 \or
1709 \expandafter\XINT_mul_Mr_one
1710 \else
1711 \expandafter\XINT_mul_Nr
1712 \fi
1713 {0000}{\{#1}%
1714 }%
1715 \def\XINT_mul_Mr_zero #1\Z\Z\Z\Z { 0000}%
1716 \def\XINT_mul_Mr_one #1#2#3#4\Z\Z\Z\Z { #4}%
1717 \def\XINT_mul_Nr #1#2#3#4#5#6#7%
1718 {%
1719 \xint_gob_til_Z #4\xint_mul_pr\Z\XINT_mul_Pr {#1}{#3}{#7#6#5#4}{#2}{#3}%
1720 }%
1721 \def\XINT_mul_Pr #1#2#3%
1722 {%
1723 \expandafter\XINT_mul_Lr\the\numexpr \xint_c_x^viii+#1+#2*#3\relax
1724 }%
1725 \def\XINT_mul_Lr 1#1#2#3#4#5#6#7#8#9%
1726 {%
1727 \XINT_mul_Nr {#1#2#3#4}{#9#8#7#6#5}%
1728 }%
1729 \def\xint_mul_pr\Z\XINT_mul_Pr #1#2#3#4#5%
1730 {%
1731 \xint_gob_til_zeros_iv #1\XINT_mul_Mr_end_nocarry 0000%
1732 \XINT_mul_Mr_end_carry #1{#4}%
1733 }%
1734 \def\XINT_mul_Mr_end_nocarry 0000\XINT_mul_Mr_end_carry 0000#1{ #1}%
1735 \def\XINT_mul_Mr_end_carry #1#2#3#4#5{ #5#4#3#2#1}%

<< Petite >> multiplication. renvoie le résultat *à l'endroit*, avec *nettoyage
des leading zéros*.
\romannumeral0\XINT_mul_M {<n>}<N>\Z\Z\Z\Z
Fait la multiplication de <N> par <n>, qui est < 10000. <N> est présenté *à
l'envers*, sur *4n*.

1736 \def\XINT_mul_M #1%
1737 {%
1738 \expandafter\XINT_mul_M_checkifzeroorone\expandafter{\the\numexpr #1}%
1739 }%
1740 \def\XINT_mul_M_checkifzeroorone #1%
1741 {%
1742 \ifcase #1
1743 \expandafter\XINT_mul_M_zero
1744 \or
1745 \expandafter\XINT_mul_M_one
1746 \else
1747 \expandafter\XINT_mul_N
1748 \fi

```

```

1749 {0000}{\}{#1}%
1750 }%
1751 \def\XINT_mul_M_zero #1\Z\Z\Z\Z { 0}%
1752 \def\XINT_mul_M_one #1#2#3#4\Z\Z\Z\Z
1753 {%
1754 \expandafter\xint_cleanupzeros_andstop\romannumeral0\xintreverseorder{#4}%
1755 }%
1756 \def\XINT_mul_N #1#2#3#4#5#6#7%
1757 {%
1758 \xint_gob_til_Z #4\xint_mul_p\Z\XINT_mul_P {#1}{#3}{#7#6#5#4}{#2}{#3}%
1759 }%
1760 \def\XINT_mul_P #1#2#3%
1761 {%
1762 \expandafter\XINT_mul_L\the\numexpr \xint_c_x^viii+#1+#2*#3\relax
1763 }%
1764 \def\XINT_mul_L #1#2#3#4#5#6#7#8#9%
1765 {%
1766 \XINT_mul_N {#1#2#3#4}{#5#6#7#8#9}%
1767 }%
1768 \def\xint_mul_p\Z\XINT_mul_P #1#2#3#4#5%
1769 {%
1770 \XINT_mul_M_end #1#4%
1771 }%
1772 \edef\XINT_mul_M_end #1#2#3#4#5#6#7#8%
1773 {%
1774 \noexpand\expandafter\space\noexpand\the\numexpr #1#2#3#4#5#6#7#8\relax
1775 }%

```

Routine de multiplication principale (attention délimiteurs modifiés pour 1.08)  
 Le résultat partiel est toujours maintenu avec significatif à droite et il a un nombre multiple de 4 de chiffres

\romannumeral0\XINT\_mul\_enter <N1>\Z\Z\Z\Z <N2>\W\W\W\W

avec <N1> \*renversé\*, \*longueur 4n\* (zéros éventuellement ajoutés au-delà du chiffre le plus significatif) et <N2> dans l'ordre \*normal\*, et pas forcément longueur 4n. pas de signes.

Pour 1.08: dans \XINT\_mul\_enter et les modifs de 1.03 qui filtrent les courts, on pourrait croire que le second opérande a au moins quatre chiffres; mais le problème c'est que ceci est appelé par \XINT\_sqr. Et de plus \XINT\_sqr est utilisé dans la nouvelle routine d'extraction de racine carrée: je ne veux pas rajouter l'overhead à \XINT\_sqr de voir si la longueur est au moins 4. Dilemme donc. Il ne semble pas y avoir d'autres accès directs (celui de big fac n'est pas un problème). J'ai presque été tenté de faire du 5x4, mais si on veut maintenir les résultats intermédiaires sur 4n, il y a des complications. Par ailleurs, je modifie aussi un petit peu la façon de coder la suite, compte tenu du style que j'ai développé ultérieurement. Attention terminaison modifiée pour le deuxième opérande.

```

1776 \def\XINT_mul_enter #1\Z\Z\Z\Z #2#3#4#5%
1777 {%
1778 \xint_gob_til_W #5\XINT_mul_exit_a\W
1779 \XINT_mul_start {#2#3#4#5}{#1\Z\Z\Z\Z

```

```

1780 }%
1781 \def\XINT_mul_exit_a\W\XINT_mul_start #1%
1782 {%
1783   \XINT_mul_exit_b #1%
1784 }%
1785 \def\XINT_mul_exit_b #1#2#3#4%
1786 {%
1787   \xint_gob_til_W
1788   #2\XINT_mul_exit_ci
1789   #3\XINT_mul_exit_cii
1790   \W\XINT_mul_exit_ciii #1#2#3#4%
1791 }%
1792 \def\XINT_mul_exit_ciii #1\W #2\Z\Z\Z\Z \W\W\W
1793 {%
1794   \XINT_mul_M {#1}#2\Z\Z\Z\Z
1795 }%
1796 \def\XINT_mul_exit_cii\W\XINT_mul_exit_ciii #1\W\W #2\Z\Z\Z\Z \W\W
1797 {%
1798   \XINT_mul_M {#1}#2\Z\Z\Z\Z
1799 }%
1800 \def\XINT_mul_exit_ci\W\XINT_mul_exit_cii
1801   \W\XINT_mul_exit_ciii #1\W\W\W #2\Z\Z\Z\Z \W
1802 {%
1803   \XINT_mul_M {#1}#2\Z\Z\Z\Z
1804 }%
1805 \def\XINT_mul_start #1#2\Z\Z\Z\Z
1806 {%
1807   \expandafter\XINT_mul_main\expandafter
1808   {\romannumeral0\XINT_mul_Mr {#1}#2\Z\Z\Z\Z}#2\Z\Z\Z\Z
1809 }%
1810 \def\XINT_mul_main #1#2\Z\Z\Z\Z #3#4#5#6%
1811 {%
1812   \xint_gob_til_W #6\XINT_mul_finish_a\W
1813   \XINT_mul_compute {#3#4#5#6}{#1}#2\Z\Z\Z\Z
1814 }%
1815 \def\XINT_mul_compute #1#2#3\Z\Z\Z\Z
1816 {%
1817   \expandafter\XINT_mul_main\expandafter
1818   {\romannumeral0\expandafter
1819   \XINT_mul_Ar\expandafter0\expandafter{\expandafter}%
1820   \romannumeral0\XINT_mul_Mr {#1}#3\Z\Z\Z\Z
1821   \W\X\Y\Z 0000#2\W\X\Y\Z }#3\Z\Z\Z\Z
1822 }%

```

Ici, le deuxième nombre se termine. Fin du calcul. On utilise la variante `\XINT_addm_A` de l'addition car on sait que le deuxième terme est au moins aussi long que le premier. Lorsque le multiplicateur avait longueur  $4n$ , la dernière addition a fourni le résultat à l'envers, il faut donc encore le renverser.

```

1823 \def\XINT_mul_finish_a\W\XINT_mul_compute #1%

```

```

1824 {%
1825     \XINT_mul_finish_b #1%
1826 }%
1827 \def\XINT_mul_finish_b #1#2#3#4%
1828 {%
1829     \xint_gob_til_W
1830     #1\XINT_mul_finish_c
1831     #2\XINT_mul_finish_ci
1832     #3\XINT_mul_finish_cii
1833     \W\XINT_mul_finish_ciii #1#2#3#4%
1834 }%
1835 \def\XINT_mul_finish_ciii #1\W #2#3\Z\Z\Z\Z \W\W\W
1836 {%
1837     \expandafter\XINT_addm_A\expandafter0\expandafter{\expandafter}%
1838     \romannumeral0\XINT_mul_Mr {#1}#3\Z\Z\Z\Z \W\X\Y\Z 000#2\W\X\Y\Z
1839 }%
1840 \def\XINT_mul_finish_cii
1841     \W\XINT_mul_finish_ciii #1\W\W #2#3\Z\Z\Z\Z \W\W
1842 {%
1843     \expandafter\XINT_addm_A\expandafter0\expandafter{\expandafter}%
1844     \romannumeral0\XINT_mul_Mr {#1}#3\Z\Z\Z\Z \W\X\Y\Z 00#2\W\X\Y\Z
1845 }%
1846 \def\XINT_mul_finish_ci #1\XINT_mul_finish_ciii #2\W\W\W #3#4\Z\Z\Z\Z \W
1847 {%
1848     \expandafter\XINT_addm_A\expandafter0\expandafter{\expandafter}%
1849     \romannumeral0\XINT_mul_Mr {#2}#4\Z\Z\Z\Z \W\X\Y\Z 0#3\W\X\Y\Z
1850 }%
1851 \def\XINT_mul_finish_c #1\XINT_mul_finish_ciii \W\W\W\W #2#3\Z\Z\Z\Z
1852 {%
1853     \expandafter\xint_cleanupzeros_andstop\romannumeral0\xintreverseorder{#2}%
1854 }%

```

Variante de la Multiplication

\romannumeral0\XINT\_mulr\_enter <N1>\Z\Z\Z\Z <N2>\W\W\W\W

Ici <N1> est à l'envers sur 4n, et <N2> est à l'endroit, pas sur 4n, comme dans \XINT\_mul\_enter, mais le résultat est lui-même fourni \*à l'envers\*, sur \*4n\* (en faisant attention de ne pas avoir 0000 à la fin).

Utilisé par le calcul des puissances. J'ai modifié dans 1.08 sur le modèle de la nouvelle version de \XINT\_mul\_enter. Je pourrais économiser des macros et fusionner \XINT\_mul\_enter et \XINT\_mulr\_enter. Une autre fois.

```

1855 \def\XINT_mulr_enter #1\Z\Z\Z\Z #2#3#4#5%
1856 {%
1857     \xint_gob_til_W #5\XINT_mulr_exit_a\W
1858     \XINT_mulr_start {#2#3#4#5}#1\Z\Z\Z\Z
1859 }%
1860 \def\XINT_mulr_exit_a\W\XINT_mulr_start #1%
1861 {%
1862     \XINT_mulr_exit_b #1%
1863 }%

```

### 36 Package *xint* implementation

```

1864 \def\XINT_mulr_exit_b #1#2#3#4%
1865 {%
1866   \xint_gob_til_W
1867   #2\XINT_mulr_exit_ci
1868   #3\XINT_mulr_exit_cii
1869   \W\XINT_mulr_exit_ciii #1#2#3#4%
1870 }%
1871 \def\XINT_mulr_exit_ciii #1\W #2\Z\Z\Z\Z \W\W\W
1872 {%
1873   \XINT_mul_Mr {#1}#2\Z\Z\Z\Z
1874 }%
1875 \def\XINT_mulr_exit_cii\W\XINT_mulr_exit_ciii #1\W\W #2\Z\Z\Z\Z \W\W
1876 {%
1877   \XINT_mul_Mr {#1}#2\Z\Z\Z\Z
1878 }%
1879 \def\XINT_mulr_exit_ci\W\XINT_mulr_exit_cii
1880   \W\XINT_mulr_exit_ciii #1\W\W\W #2\Z\Z\Z\Z \W
1881 {%
1882   \XINT_mul_Mr {#1}#2\Z\Z\Z\Z
1883 }%
1884 \def\XINT_mulr_start #1#2\Z\Z\Z\Z
1885 {%
1886   \expandafter\XINT_mulr_main\expandafter
1887   {\romannumeral0\XINT_mul_Mr {#1}#2\Z\Z\Z\Z}#2\Z\Z\Z\Z
1888 }%
1889 \def\XINT_mulr_main #1#2\Z\Z\Z\Z #3#4#5#6%
1890 {%
1891   \xint_gob_til_W #6\XINT_mulr_finish_a\W
1892   \XINT_mulr_compute {#3#4#5#6}{#1}#2\Z\Z\Z\Z
1893 }%
1894 \def\XINT_mulr_compute #1#2#3\Z\Z\Z\Z
1895 {%
1896   \expandafter\XINT_mulr_main\expandafter
1897   {\romannumeral0\expandafter
1898   \XINT_mul_Ar\expandafter0\expandafter{\expandafter}%
1899   \romannumeral0\XINT_mul_Mr {#1}#3\Z\Z\Z\Z
1900   \W\X\Y\Z 0000#2\W\X\Y\Z }#3\Z\Z\Z\Z
1901 }%
1902 \def\XINT_mulr_finish_a\W\XINT_mulr_compute #1%
1903 {%
1904   \XINT_mulr_finish_b #1%
1905 }%
1906 \def\XINT_mulr_finish_b #1#2#3#4%
1907 {%
1908   \xint_gob_til_W
1909   #1\XINT_mulr_finish_c
1910   #2\XINT_mulr_finish_ci
1911   #3\XINT_mulr_finish_cii
1912   \W\XINT_mulr_finish_ciii #1#2#3#4%

```

```

1913 }%
1914 \def\XINT_mulr_finish_ciii #1\W #2#3\Z\Z\Z\Z \W\W\W
1915 {%
1916   \expandafter\XINT_addp_A\expandafter0\expandafter{\expandafter}%
1917   \romannumeral0\XINT_mul_Mr {#1}#3\Z\Z\Z\Z \W\X\Y\Z 000#2\W\X\Y\Z
1918 }%
1919 \def\XINT_mulr_finish_cii
1920   \W\XINT_mulr_finish_ciii #1\W\W #2#3\Z\Z\Z\Z \W\W
1921 {%
1922   \expandafter\XINT_addp_A\expandafter0\expandafter{\expandafter}%
1923   \romannumeral0\XINT_mul_Mr {#1}#3\Z\Z\Z\Z \W\X\Y\Z 00#2\W\X\Y\Z
1924 }%
1925 \def\XINT_mulr_finish_ci #1\XINT_mulr_finish_ciii #2\W\W\W #3#4\Z\Z\Z\Z \W
1926 {%
1927   \expandafter\XINT_addp_A\expandafter0\expandafter{\expandafter}%
1928   \romannumeral0\XINT_mul_Mr {#2}#4\Z\Z\Z\Z \W\X\Y\Z 0#3\W\X\Y\Z
1929 }%
1930 \def\XINT_mulr_finish_c #1\XINT_mulr_finish_ciii \W\W\W\W #2#3\Z\Z\Z\Z { #2}%

```

### 36.44 \xintSqr

```

1931 \def\xintiisqr {\romannumeral0\xintiisqr }%
1932 \def\xintiisqr #1%
1933 {%
1934   \expandafter\XINT_sqr\expandafter {\romannumeral0\xintiabs{#1}}%
1935 }%
1936 \def\xintiSqr {\romannumeral0\xintisqr }%
1937 \def\xintisqr #1%
1938 {%
1939   \expandafter\XINT_sqr\expandafter {\romannumeral0\xintiabs{#1}}%
1940 }%
1941 \let\xintSqr\xintiSqr \let\xintsqr\xintisqr
1942 \def\XINT_sqr #1%
1943 {%
1944   \expandafter\XINT_mul_enter
1945   \romannumeral0%
1946   \XINT_RQ {}#1\R\R\R\R\R\R\R\Z
1947   \Z\Z\Z\Z #1\W\W\W\W
1948 }%

```

### 36.45 \xintPrd

```

\xintPrd {{a}...{z}}
\xintPrdExpr {a}...{z}\relax

```

Release 1.02 modified the product routine. The earlier version was faster in situations where each new term is bigger than the product of all previous terms, a situation which arises in the algorithm for computing powers. The 1.02 version was changed to be more efficient on big products, where the new term is small compared to what has been computed so far (the power algorithm now has its own product routine).

Finally, the 1.03 version just simplifies everything as the multiplication now decides what is best, with the price of a little overhead. So the code has been dramatically reduced here.

In 1.03 I also modify the way `\xintPrd` and `\xintPrdExpr ... \relax` are related. Now `\xintPrdExpr \z \relax` is accepted input when `\z` expands to a list of braced terms (prior only `\xintPrd { \z }` or `\xintPrd \z` was possible).

In 1.06a I suddenly decide that `\xintProductExpr` was a silly name, and as the package is new and certainly not used, I decide I may just switch to `\xintPrdExpr` which I should have used from the beginning.

1.09a does NOT add the `\xintnum` overhead. 1.09h renames `\xintiPrd` to `\xintiiPrd` to correctly reflect this.

```

1949 \def\xintiiPrd {\romannumeral0\xintiiprd }%
1950 \def\xintiiprd #1{\xintiiprdexpr #1\relax }%
1951 \let\xintPrd\xintiiPrd
1952 \let\xintprd\xintiiPrd
1953 \def\xintiiPrdExpr {\romannumeral0\xintiiprdexpr }%
1954 \def\xintiiprdexpr {\expandafter\xint_prdexpr\romannumeral-'0}%
1955 \let\xintPrdExpr\xintiiPrdExpr
1956 \let\xintprdexpr\xintiiprdexpr
1957 \def\xint_prdexpr {\XINT_prod_loop_a 1\Z }%
1958 \def\xint_prod_loop_a #1\Z #2%
1959     {\expandafter\xint_prod_loop_b \romannumeral-'0#2\Z #1\Z \Z}%
1960 \def\xint_prod_loop_b #1%
1961     {\xint_gob_til_relax #1\xint_prod_finished\relax\xint_prod_loop_c #1}%
1962 \def\xint_prod_loop_c
1963     {\expandafter\xint_prod_loop_a\romannumeral0\xint_mul_fork }%
1964 \def\xint_prod_finished #1\Z #2\Z \Z { #2}%

```

### 36.46 `\xintFac`

Modified with 1.02 and again in 1.03 for greater efficiency. I am tempted, here and elsewhere, to use `\ifcase\xint_Geq {#1}{10000000000}` rather than `\ifnum\xintLength {#1}>9` but for the time being I leave things as they stand. With release 1.05, rather than using `\xintLength` I opt finally for direct use of `\numexpr` (which will throw a suitable number too big message), and to raise the `\xintError: FactorialOfTooBigNumber` for argument larger than 10000000 (rather than 10000000000). With 1.09a, `\xintFac` uses `\xintnum`.

1.09j for no special reason, I lower the maximal number from 999999 to 1000000. Any how this computation would need more memory than TL2013 standard allows to TeX. And I don't even mention time...

```

1965 \def\xintiFac {\romannumeral0\xintifac }%
1966 \def\xintifac #1%
1967 {%
1968     \expandafter\xint_fac_fork\expandafter{\the\numexpr #1}%
1969 }%
1970 \let\xintFac\xintiFac \let\xintfac\xintifac
1971 \def\xint_fac_fork #1%

```

```

1972 {%
1973   \ifcase\XINT_cntSgn #1\Z
1974     \xint_afterfi{\expandafter\space\expandafter 1\xint_gobble_i }%
1975   \or
1976     \expandafter\XINT_fac_checklength
1977   \else
1978     \xint_afterfi{\expandafter\xintError:FactorialOfNegativeNumber
1979       \expandafter\space\expandafter 1\xint_gobble_i }%
1980   \fi
1981   {#1}%
1982 }%
1983 \def\XINT_fac_checklength #1%
1984 {%
1985   \ifnum #1>100000
1986     \xint_afterfi{\expandafter\xintError:FactorialOfTooBigNumber
1987       \expandafter\space\expandafter 1\xint_gobble_i }%
1988   \else
1989     \xint_afterfi{\ifnum #1>\xint_c_ixixix
1990       \expandafter\XINT_fac_big_loop
1991       \else
1992         \expandafter\XINT_fac_loop
1993       \fi }%
1994   \fi
1995   {#1}%
1996 }%
1997 \def\XINT_fac_big_loop #1{\XINT_fac_big_loop_main {10000}{#1}{}}%
1998 \def\XINT_fac_big_loop_main #1#2#3%
1999 {%
2000   \ifnum #1<#2
2001     \expandafter
2002       \XINT_fac_big_loop_main
2003     \expandafter
2004       {\the\numexpr #1+1\expandafter }%
2005   \else
2006     \expandafter\XINT_fac_big_docomputation
2007   \fi
2008   {#2}{#3{#1}}%
2009 }%
2010 \def\XINT_fac_big_docomputation #1#2%
2011 {%
2012   \expandafter \XINT_fac_bigcompute_loop \expandafter
2013   {\romannumeral0\XINT_fac_loop {9999}}#2\relax
2014 }%
2015 \def\XINT_fac_bigcompute_loop #1#2%
2016 {%
2017   \xint_gob_til_relax #2\XINT_fac_bigcompute_end\relax
2018   \expandafter\XINT_fac_bigcompute_loop\expandafter
2019   {\expandafter\XINT_mul_enter
2020     \romannumeral0\XINT_RQ {}#2\R\R\R\R\R\R\R\R\Z

```

```

2021      \Z\Z\Z\Z #1\W\W\W\W }%
2022 }%
2023 \def\XINT_fac_bigcompute_end #1#2#3#4#5%
2024 {%
2025      \XINT_fac_bigcompute_end_ #5%
2026 }%
2027 \def\XINT_fac_bigcompute_end_ #1\R #2\Z \W\X\Y\Z #3\W\X\Y\Z { #3}%
2028 \def\XINT_fac_loop #1{\XINT_fac_loop_main 1{1000}{#1}}%
2029 \def\XINT_fac_loop_main #1#2#3%
2030 {%
2031      \ifnum #3>#1
2032      \else
2033          \expandafter\XINT_fac_loop_exit
2034      \fi
2035      \expandafter\XINT_fac_loop_main\expandafter
2036      {\the\numexpr #1+1\expandafter }\expandafter
2037      {\romannumeral0\XINT_mul_Mr {#1}#2\Z\Z\Z }%
2038      {#3}%
2039 }%
2040 \def\XINT_fac_loop_exit #1#2#3#4#5#6#7%
2041 {%
2042      \XINT_fac_loop_exit_ #6%
2043 }%
2044 \def\XINT_fac_loop_exit_ #1#2#3%
2045 {%
2046      \XINT_mul_M
2047 }%

```

### 36.47 \xintPow

1.02 modified the \XINT\_posprod routine, the was renamed \XINT\_pow\_posprod and moved here, as it was well adapted for computing powers. Then 1.03 moved the special variants of multiplication (hence of addition) which were needed to earlier in this style file.

Modified in 1.06, the exponent is given to a \numexpr rather than twice expanded. \xintnum added in 1.09a.

\XINT\_pow\_posprod: Routine de produit servant pour le calcul des puissances. Chaque nouveau terme est plus grand que ce qui a déjà été calculé. Par conséquent on a intérêt à le conserver en second dans la routine de multiplication, donc le précédent calcul a intérêt à avoir été donné sur  $4n$ , à l'envers. Il faut donc modifier la multiplication pour qu'elle fasse cela. Ce qui oblige à utiliser une version spéciale de l'addition également.

1.09j has reorganized the main loop, the described above \XINT\_pow\_posprod routine has been removed, intermediate multiplications are done immediately. Also, the maximal accepted exponent is now 1000000 (no such restriction in \xint-FloatPow, which accepts any exponent less than  $2^{31}$ , and in \xintFloatPower which accepts long integers as exponent).

$2^{1000000} = 9.990020930143845e30102$  and multiplication of two numbers with 30000 digits would take hours on my laptop (seconds for 1000 digits).

```

2048 \def\xintiiPow {\romannumeral0\xintiipow }%
2049 \def\xintiipow #1%
2050 {%
2051   \expandafter\xint_pow\romannumeral-‘0#1\Z%
2052 }%
2053 \def\xintiPow {\romannumeral0\xintipow }%
2054 \def\xintipow #1%
2055 {%
2056   \expandafter\xint_pow\romannumeral0\xintnum{#1}\Z%
2057 }%
2058 \let\xintPow\xintiPow \let\xintpow\xintipow
2059 \def\xint_pow #1#2\Z
2060 {%
2061   \xint_UDsignfork
2062     #1\XINT_pow_Aneg
2063     -\XINT_pow_Anonneg
2064   \krof
2065     #1{#2}%
2066 }%
2067 \def\XINT_pow_Aneg #1#2#3%
2068 {%
2069   \expandafter\XINT_pow_Aneg_\expandafter{\the\numexpr #3}{#2}%
2070 }%
2071 \def\XINT_pow_Aneg_ #1%
2072 {%
2073   \ifodd #1
2074     \expandafter\XINT_pow_Aneg_Bodd
2075   \fi
2076   \XINT_pow_Anonneg_ {#1}%
2077 }%
2078 \def\XINT_pow_Aneg_Bodd #1%
2079 {%
2080   \expandafter\XINT_opp\romannumeral0\XINT_pow_Anonneg_
2081 }%

B = #3, faire le xpxp. Modified with 1.06: use of \numexpr.

2082 \def\XINT_pow_Anonneg #1#2#3%
2083 {%
2084   \expandafter\XINT_pow_Anonneg_\expandafter {\the\numexpr #3}{#1#2}%
2085 }%

#1 = B, #2 = |A|

2086 \def\XINT_pow_Anonneg_ #1#2%
2087 {%
2088   \ifcase\XINT_Cmp {#2}{1}
2089     \expandafter\XINT_pow_AisOne
2090   \or
2091     \expandafter\XINT_pow_AatleastTwo

```

```

2092 \else
2093 \expandafter\XINT_pow_AisZero
2094 \fi
2095 {#1}{#2}%
2096 }%
2097 \def\XINT_pow_AisOne #1#2{ 1}%

#1 = B

2098 \def\XINT_pow_AisZero #1#2%
2099 {%
2100 \ifcase\XINT_cntSgn #1\Z
2101 \xint_afterfi { 1}%
2102 \or
2103 \xint_afterfi { 0}%
2104 \else
2105 \xint_afterfi {\xintError:DivisionByZero\space 0}%
2106 \fi
2107 }%
2108 \def\XINT_pow_AatleastTwo #1%
2109 {%
2110 \ifcase\XINT_cntSgn #1\Z
2111 \expandafter\XINT_pow_BisZero
2112 \or
2113 \expandafter\XINT_pow_checkBsize
2114 \else
2115 \expandafter\XINT_pow_BisNegative
2116 \fi
2117 {#1}%
2118 }%
2119 \edef\XINT_pow_BisNegative #1#2%
2120 {\noexpand\xintError:FractionRoundedToZero\space 0}%
2121 \def\XINT_pow_BisZero #1#2{ 1}%

B = #1 > 0, A = #2 > 1. With 1.05, I replace \xintiLen{#1}>9 by direct use of \numexpr
[to generate an error message if the exponent is too large] 1.06: \numexpr was
already used above.

2122 \def\XINT_pow_checkBsize #1%
2123 {%
2124 \ifnum #1>1000000
2125 \expandafter\XINT_pow_BtooBig
2126 \else
2127 \expandafter\XINT_pow_loopI
2128 \fi
2129 {#1}%
2130 }%
2131 \edef\XINT_pow_BtooBig #1#2{\noexpand\xintError:ExponentTooBig\space 0}%
2132 \def\XINT_pow_loopI #1%
2133 {%

```

```

2134 \ifnum #1=\xint_c_i\XINT_pow_Iend\fi
2135 \ifodd #1
2136 \expandafter\XINT_pow_loopI_odd
2137 \else
2138 \expandafter\XINT_pow_loopI_even
2139 \fi
2140 {#1}%
2141 }%
2142 \edef\XINT_pow_Iend\fi #1\fi #2#3{\noexpand\fi\space #3}%
2143 \def\XINT_pow_loopI_even #1#2%
2144 {%
2145 \expandafter\XINT_pow_loopI\expandafter
2146 {\the\numexpr #1/\xint_c_ii\expandafter}\expandafter
2147 {\romannumeral0\xintiisqr {#2}}%
2148 }%
2149 \def\XINT_pow_loopI_odd #1#2%
2150 {%
2151 \expandafter\XINT_pow_loopI_odda\expandafter
2152 {\romannumeral0\XINT_RQ {}#2\R\R\R\R\R\R\R\R\Z }{#1}{#2}%
2153 }%
2154 \def\XINT_pow_loopI_odda #1#2#3%
2155 {%
2156 \expandafter\XINT_pow_loopII\expandafter
2157 {\the\numexpr #2/\xint_c_ii-\xint_c_i\expandafter}\expandafter
2158 {\romannumeral0\xintiisqr {#3}}{#1}%
2159 }%
2160 \def\XINT_pow_loopII #1%
2161 {%
2162 \ifnum #1 = \xint_c_i\XINT_pow_IIend\fi
2163 \ifodd #1
2164 \expandafter\XINT_pow_loopII_odd
2165 \else
2166 \expandafter\XINT_pow_loopII_even
2167 \fi
2168 {#1}%
2169 }%
2170 \def\XINT_pow_loopII_even #1#2%
2171 {%
2172 \expandafter\XINT_pow_loopII\expandafter
2173 {\the\numexpr #1/\xint_c_ii\expandafter}\expandafter
2174 {\romannumeral0\xintiisqr {#2}}%
2175 }%
2176 \def\XINT_pow_loopII_odd #1#2#3%
2177 {%
2178 \expandafter\XINT_pow_loopII_odda\expandafter
2179 {\romannumeral0\XINT_mulr_enter #3\Z\Z\Z\Z #2\W\W\W\W}{#1}{#2}%
2180 }%
2181 \def\XINT_pow_loopII_odda #1#2#3%
2182 {%

```

```

2183 \expandafter\XINT_pow_loopII\expandafter
2184 {\the\numexpr #2/\xint_c_ii-\xint_c_i\expandafter}\expandafter
2185 {\romannumeral0\xintiisqr {#3}}{#1}%
2186 }%
2187 \def\XINT_pow_IIend\fi #1\fi #2#3#4%
2188 {%
2189 \fi\XINT_mul_enter #4\Z\Z\Z\Z #3\W\W\W\W
2190 }%

```

### 36.48 \xintDivision, \xintQuo, \xintRem

The 1.09a release inserted the use of \xintnum. The \xintiDivision etc... are the ones which do only \romannumeral-‘0.

January 5, 2014: Naturally, addition, subtraction, multiplication and division are the first things I did and since then I had left the division untouched. So in preparation of release 1.09j, I started revisiting the division, I did various minor improvements obtaining roughly 10% efficiency gain. Then I decided I should deliberately impact the input save stack, with the hope to gain more speed from removing tokens and leaving them upstream.

For this however I had to modify the underlying mathematical algorithm. The initial one is a bit unusual I guess, and, I trust, rather efficient, but it does not produce the quotient digits (in base 10000) one by one; at any given time it is possible that some correction will be made, which means it is not an appropriate algorithm for a TeX implementation which will abandon the quotient upstream. Thus I now have with 1.09j a new underlying mathematical algorithm, presumably much more standard. It is a bit complicated to implement expandably these things, but in the end I had regained the already mentioned 10% efficiency and even more for small to medium sized inputs (up to 30% perhaps). And in passing I did a special routine for divisors < 10000, which is 5 to 10 times faster still.

But, I then tested a variant of my new implementation which again did not impact the input save stack and, for sizes of up to 200 digits, it is not much worse, indeed it is perhaps actually better than the one abandoning the quotient digits upstream (and in the end putting them in the correct order). So, finally, I re-incorporated the produced quotient digits within a tail recursion. Hence \xintDivision, like all other routines in xint (except \xintSeq without optional parameter) still does not impact the input save stack. One can have a produced quotient longer than  $4 \times 5000 = 20000$  digits, and no need to worry about \xintTrunc, \xintRound, \xintFloat, \xintFloatSqrt, etc... and all other places using the division.

However outputting to a file (which is basically the only thing one can do, multiplying out two 20000 digits numbers already takes hours, for 100000 it would be days if not weeks) 100000 digits is slow... the truncation routine will add 100000 zeros (circa) and then trim them four by four. Definitely I should do a routine XTrunc which will work by blocks of say 64, and furthermore, being destined to be used in and \edef or a \write, it could be much more efficient as it could simply be based on tail loop, which so far nothing in xint does because I want things to expand fully under \romannumeral-‘0 (and don’t imagine inserting chains of thousands of \expandafter’s...) in order to be nestable. Inside \xintexpr such style of tail recursion leaving downstream things should definitely

be implemented for the routines for which it is possible as things get expanded inside `\csname..\endcsname`. I don't do yet anything like this for 1.09j.

```

2191 \def\xintiiQuo {\romannumeral0\xintiiquo }%
2192 \def\xintiiRem {\romannumeral0\xintiirem }%
2193 \def\xintiiquo {\expandafter\xint_firstoftwo_thenstop
2194                  \romannumeral0\xintiidivision }%
2195 \def\xintiirem {\expandafter\xint_secondoftwo_thenstop
2196                \romannumeral0\xintiidivision }%
2197 \def\xintQuo {\romannumeral0\xintquo }%
2198 \def\xintRem {\romannumeral0\xintrem }%
2199 \def\xintquo {\expandafter\xint_firstoftwo_thenstop
2200               \romannumeral0\xintdivision }%
2201 \def\xintrem {\expandafter\xint_secondoftwo_thenstop
2202              \romannumeral0\xintdivision }%

```

#1 = A, #2 = B. On calcule le quotient et le reste dans la division euclidienne de A par B.

```

2203 \def\xintiiDivision {\romannumeral0\xintiidivision }%
2204 \def\xintiidivision #1%
2205 {%
2206   \expandafter\xint_iidivision\expandafter {\romannumeral-‘0#1}%
2207 }%
2208 \def\xint_iidivision #1#2%
2209 {%
2210   \expandafter\XINT_div_fork \romannumeral-‘0#2\Z #1\Z
2211 }%
2212 \def\xintDivision {\romannumeral0\xintdivision }%
2213 \def\xintdivision #1%
2214 {%
2215   \expandafter\xint_division\expandafter {\romannumeral0\xintnum{#1}}%
2216 }%
2217 \def\xint_division #1#2%
2218 {%
2219   \expandafter\XINT_div_fork \romannumeral0\xintnum{#2}\Z #1\Z
2220 }%

```

#1#2 = 2e input = diviseur = B. #3#4 = 1er input = divisé = A.

```

2221 \def\XINT_div_fork #1#2\Z #3#4\Z
2222 {%
2223   \xint_UDzerofork
2224   #1\XINT_div_BisZero
2225   #3\XINT_div_AisZero
2226   0{\xint_UDsignfork
2227     #1\XINT_div_BisNegative % B < 0
2228     #3\XINT_div_AisNegative % A < 0, B > 0
2229     -\XINT_div_plusplus    % B > 0, A > 0
2230   \krof }%

```

```

2231 \krof
2232 {#2}{#4}#1#3% #1#2=B, #3#4=A
2233 }%
2234 \edef\XINT_div_BisZero #1#2#3#4{\noexpand\xintError:DivisionByZero\space {0}{0}}%
2235 \def\XINT_div_AisZero #1#2#3#4{ {0}{0}}%

  jusqu'à présent c'est facile.
  minusplus signifie  $B < 0$ ,  $A > 0$ 
  plusminus signifie  $B > 0$ ,  $A < 0$ 
  Ici #3#1 correspond au diviseur B et #4#2 au divisé A.
  Cases with  $B < 0$  or especially  $A < 0$  are treated sub-optimally in terms of post-
  processing, things get reversed which could have been produced directly in the
  wanted order, but  $A, B > 0$  is given priority for optimization. I should revise the
  next few macros, definitely.

2236 \def\XINT_div_plusplus #1#2#3#4{\XINT_div_prepare {#3#1}{#4#2}}%

  B = #3#1 < 0, A non nul positif ou négatif

2237 \def\XINT_div_BisNegative #1#2#3#4%
2238 {%
2239   \expandafter\XINT_div_BisNegative_b
2240   \romannumeral0\XINT_div_fork #1\Z #4#2\Z
2241 }%
2242 \edef\XINT_div_BisNegative_b #1%
2243 {%
2244   \noexpand\expandafter\space\noexpand\expandafter
2245   {\noexpand\romannumeral0\noexpand\XINT_opp #1}%
2246 }%

  B = #3#1 > 0, A = -#2 < 0

2247 \def\XINT_div_AisNegative #1#2#3#4%
2248 {%
2249   \expandafter\XINT_div_AisNegative_b
2250   \romannumeral0\XINT_div_prepare {#3#1}{#2}{#3#1}%
2251 }%
2252 \def\XINT_div_AisNegative_b #1#2%
2253 {%
2254   \if0\XINT_Sgn #2\Z
2255     \expandafter \XINT_div_AisNegative_Rzero
2256   \else
2257     \expandafter \XINT_div_AisNegative_Rpositive
2258   \fi
2259   {#1}{#2}%
2260 }%

  en #3 on a une copie de B (à l'endroit)

2261 \edef\XINT_div_AisNegative_Rzero #1#2#3%

```

```

2262 {%
2263   \noexpand\expandafter\space\noexpand\expandafter
2264   {\noexpand\romannumeral0\noexpand\XINT_opp #1}{0}%
2265 }%

#1 = quotient, #2 = reste, #3 = diviseur initial (à l'endroit) remplace Reste par
B - Reste, après avoir remplacé Q par -(Q+1) de sorte que la formule  $a = qb + r$ ,  $0 \leq r < |b|$  est valable

2266 \def\XINT_div_AisNegative_Rpositive #1%
2267 {%
2268   \expandafter \XINT_div_AisNegative_Rpositive_b \expandafter
2269   {\romannumeral0\xintiioopp{\xintInc {#1}}}%
2270 }%
2271 \def\XINT_div_AisNegative_Rpositive_b #1#2#3%
2272 {%
2273   \expandafter \xint_exchangetwo_keepbraces_thenstop \expandafter
2274   {\romannumeral0\XINT_sub {#3}{#2}}{#1}%
2275 }%

Pour la suite A et B sont  $> 0$ . #1 = B. Pour le moment à l'endroit. Calcul du plus
petit  $K = 4n \geq$  longueur de B

2276 \def\XINT_div_prepare #1%
2277 {%
2278   \expandafter \XINT_div_prepareB_aa \expandafter
2279   {\romannumeral0\xintlength {#1}}{#1}% B  $> 0$  ici
2280 }%
2281 \def\XINT_div_prepareB_aa #1%
2282 {%
2283   \ifnum #1=\xint_c_i
2284     \expandafter\XINT_div_prepareB_onedigit
2285   \else
2286     \expandafter\XINT_div_prepareB_a
2287   \fi
2288   {#1}%
2289 }%
2290 \def\XINT_div_prepareB_a #1%
2291 {%
2292   \expandafter\XINT_div_prepareB_c\expandafter
2293   {\the\numexpr \xint_c_iv*((#1+\xint_c_i)/\xint_c_iv)}{#1}%
2294 }%

B=1 and B=2 treated specially.

2295 \def\XINT_div_prepareB_onedigit #1#2%
2296 {%
2297   \ifcase#2
2298   \or\expandafter\XINT_div_BisOne
2299   \or\expandafter\XINT_div_BisTwo

```

```

2300 \else\expandafter\XINT_div_prepareB_e
2301 \fi {000}{0}{4}{#2}%
2302 }%
2303 \def\XINT_div_BisOne #1#2#3#4#5{ {#5}{0}}%
2304 \def\XINT_div_BisTwo #1#2#3#4#5%
2305 {%
2306 \expandafter\expandafter\expandafter\XINT_div_BisTwo_a
2307 \ifodd\xintiiLDg{#5} \expandafter1\else \expandafter0\fi {#5}%
2308 }%
2309 \edef\XINT_div_BisTwo_a #1#2%
2310 {%
2311 \noexpand\expandafter\space\noexpand\expandafter
2312 {\noexpand\romannumeral0\noexpand\xinthalft {#2}}{#1}%
2313 }%

```

#1 = K. 1.09j uses \csname, earlier versions did it with \ifcase.

```

2314 \def\XINT_div_prepareB_c #1#2%
2315 {%
2316 \csname XINT_div_prepareB_d\romannumeral\numexpr#1-#2\endcsname
2317 {#1}%
2318 }%
2319 \def\XINT_div_prepareB_d {\XINT_div_prepareB_e }{0000}}%
2320 \def\XINT_div_prepareB_di {\XINT_div_prepareB_e {0}{000}}%
2321 \def\XINT_div_prepareB_dii {\XINT_div_prepareB_e {00}{00}}%
2322 \def\XINT_div_prepareB_diii {\XINT_div_prepareB_e {000}{0}}%
2323 \def\XINT_div_cleanR #10000.{#1}}%

```

#1 = zéros à rajouter à B, #2=c [modifié dans 1.09j, ce sont maintenant des zéros explicites en nombre 4 - ancien c, et on utilisera \XINT\_div\_cleanR et non plus \XINT\_dsh\_checksngx pour nettoyer à la fin des zéros en excès dans le Reste; in all comments next, «c» stands now {0} or {00} or {000} or {0000} rather than a digit as in earlier versions], #3=K, #4 = B

```

2324 \def\XINT_div_prepareB_e #1#2#3#4%
2325 {%
2326 \ifnum#3=\xint_c_iv\expandafter\XINT_div_prepareLittleB_f
2327 \else\expandafter\XINT_div_prepareB_f
2328 \fi
2329 #4#1{#3}{#2}{#1}%
2330 }%

```

x = #1#2#3#4 = 4 premiers chiffres de B. #1 est non nul. B is reversed. With 1.09j or latter x+1 and (x+1)/2 are pre-computed. Si K=4 on ne renverse pas B, et donc B=x dans la suite. De plus pour K=4 on ne travaille pas avec x+1 et (x+1)/2 mais avec x et x/2.

```

2331 \def\XINT_div_prepareB_f #1#2#3#4#5{%
2332 \expandafter\XINT_div_prepareB_g
2333 \the\numexpr #1#2#3#4+\xint_c_i\expandafter

```

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```

2334 .\the\numexpr (#1#2#3#4+\xint_c_i)/\xint_c_ii\expandafter
2335 .\romannumeral0\xintreverseorder {#1#2#3#4#5}.\{#1#2#3#4}%
2336 }%
2337 \def\xINT_div_prepareLittleB_f #1#{%
2338   \expandafter\xINT_div_prepareB_g \the\numexpr #1/\xint_c_ii.{.}{.}{#1}%
2339 }%

#1 = x' = x+1= 1+quatre premiers chiffres de B, #2 = y = (x+1)/2 précalculé #3 =
B préparé et maintenant renversé, #4=x, #5 = K, #6 = «c», #7= {} ou {0} ou {00}
ou {000}, #8 = A initial On multiplie aussi A par 10^c. -> AK{x'yx}B«c». Par
contre dans le cas little on a #1=y=(x/2), #2={}, #3={}, #4=x, donc cela donne
->AK{y{x}}{}«c», il n'y a pas de B.

2340 \def\xINT_div_prepareB_g #1.#2.#3.#4#5#6#7#8%
2341 {%
2342   \xINT_div_prepareA_a {#8#7}{#5}{#1}{#2}{#4}{#3}{#6}%
2343 }%

A, K, {x'yx}, B«c»

2344 \def\xINT_div_prepareA_a #1%
2345 {%
2346   \expandafter\xINT_div_prepareA_b\expandafter
2347   {\romannumeral0\xintlength {#1}}{#1}%
2348 }%

L0, A, K, {x'yx}, B«c»

2349 \def\xINT_div_prepareA_b #1%
2350 {%
2351   \expandafter\xINT_div_prepareA_c\expandafter
2352   {\the\numexpr \xint_c_iv*((#1+\xint_c_i)/\xint_c_iv)}{#1}%
2353 }%

L, L0, A, K, {x'yx}, B, «C»

2354 \def\xINT_div_prepareA_c #1#2%
2355 {%
2356   \csname XINT_div_prepareA_d\romannumeral\numexpr #1-#2\endcsname
2357   {#1}%
2358 }%
2359 \def\xINT_div_prepareA_d {\xINT_div_prepareA_e {}}%
2360 \def\xINT_div_prepareA_di {\xINT_div_prepareA_e {0}}%
2361 \def\xINT_div_prepareA_dii {\xINT_div_prepareA_e {00}}%
2362 \def\xINT_div_prepareA_diii {\xINT_div_prepareA_e {000}}%

#1#3 = A préparé, #2 = longueur de ce A préparé, #4=K, #5={x'yx}-> LKAx'yxB«c»

2363 \def\xINT_div_prepareA_e #1#2#3#4#5%
2364 {%
2365   \xINT_div_start_a {#2}{#4}{#1#3}#5%
2366 }%

```

L, K, A, x', y, x, B, «c» (avec y{x} au lieu de x'yxB dans la variante little)

```

2367 \def\XINT_div_start_a #1#2%
2368 {%
2369   \ifnum #2=\xint_c_iv \expandafter\XINT_div_little_b
2370   \else
2371     \ifnum #1 < #2
2372       \expandafter\expandafter\expandafter\XINT_div_III_aa
2373     \else
2374       \expandafter\expandafter\expandafter\XINT_div_start_b
2375     \fi
2376   \fi
2377   {#1}{#2}%
2378 }%

```

L, K, A, x', y, x, B, «c».

```

2379 \def\XINT_div_III_aa #1#2#3#4#5#6#7%
2380 {%
2381   \expandafter\expandafter\expandafter
2382   \XINT_div_III_b\xint_cleanupzeros_nostop #3.{0000}%
2383 }%

```

R.Q«c».

```

2384 \def\XINT_div_III_b #1%
2385 {%
2386   \if0#1%
2387     \expandafter\XINT_div_III_bRzero
2388   \else
2389     \expandafter\XINT_div_III_bRpos
2390   \fi
2391   #1%
2392 }%
2393 \def\XINT_div_III_bRzero 0.#1#2%
2394 {%
2395   \expandafter\space\expandafter
2396   {\romannumeral0\XINT_cuz_loop #1\W\W\W\W\W\W\W\Z}{0}%
2397 }%
2398 \def\XINT_div_III_bRpos #1.#2#3%
2399 {%
2400   \expandafter\XINT_div_III_c \XINT_div_cleanR #1#3.{#2}%
2401 }%
2402 \def\XINT_div_III_c #1#2%
2403 {%
2404   \expandafter\space\expandafter
2405   {\romannumeral0\XINT_cuz_loop #2\W\W\W\W\W\W\W\Z}{#1}%
2406 }%

```

L, K, A, x', y, x, B, «c»->K.A.x{LK{x'y}x}B«c»

### 36 Package *xint* implementation

```

2407 \def\XINT_div_start_b #1#2#3#4#5#6%
2408 {%
2409   \XINT_div_start_c {#2}.#3.{#6}{#{1}{#2}{#{4}{#5}}{#6}}%
2410 }%

  Kalpha.A.x{LK{x'y}x}, B, «c», au début #2=alpha est vide

2411 \def\XINT_div_start_c #1#2.#3#4#5#6%
2412 {%
2413   \ifnum #1=\xint_c_iv\XINT_div_start_ca\fi
2414   \expandafter\XINT_div_start_c\expandafter
2415     {\the\numexpr #1-\xint_c_iv}#2#3#4#5#6.%
2416 }%
2417 \def\XINT_div_start_ca\fi\expandafter\XINT_div_start_c\expandafter
2418   #1#2#3#4#5{\fi\XINT_div_start_d {#2#3#4#5}#2#3#4#5}%

  #1=a, #2=alpha (de longueur K, à l'endroit).#3=reste de A.#4=x, #5={LK{x'y}x}, #6=B, «c»
  -> a, x, alpha, B, {0000}, L, K, {x'y}, x, alpha'=reste de A, B{«c». Pour K=4 on a
  en fait B=x, faudra revoir après.

2419 \def\XINT_div_start_d #1#2.#3.#4#5#6%
2420 {%
2421   \XINT_div_I_a {#1}{#4}{#2}{#6}{0000}#5{#3}{#6}{}%
2422 }%

  Ceci est le point de retour de la boucle principale. a, x, alpha, B, q0, L, K,
  {x'y}, x, alpha', BQ«c»

2423 \def\XINT_div_I_a #1#2%
2424 {%
2425   \expandafter\XINT_div_I_b\the\numexpr #1/#2.{#1}{#2}%
2426 }%
2427 \def\XINT_div_I_b #1%
2428 {%
2429   \xint_gob_til_zero #1\XINT_div_I_czero 0\XINT_div_I_c #1%
2430 }%

  On intercepte quotient nul: #1=a, x, alpha, B, #5=q0, L, K, {x'y}, x, alpha', BQ«c»
  -> q{alpha} L, K, {x'y}, x, alpha', BQ«c»

2431 \def\XINT_div_I_czero 0%
2432   \XINT_div_I_c 0.#1#2#3#4#5{\XINT_div_I_g {#5}{#3}}%
2433 \def\XINT_div_I_c #1.#2#3%
2434 {%
2435   \expandafter\XINT_div_I_da\the\numexpr #2-#1*#3.#1.%
2436 }%

  r.q.alpha, B, q0, L, K, {x'y}, x, alpha', BQ«c»

2437 \def\XINT_div_I_da #1.%
2438 {%

```

```

2439 \ifnum #1>\xint_c_ix
2440 \expandafter\XINT_div_I_dP
2441 \else
2442 \ifnum #1<\xint_c_
2443 \expandafter\expandafter\expandafter\XINT_div_I_dN
2444 \else
2445 \expandafter\expandafter\expandafter\XINT_div_I_db
2446 \fi
2447 \fi
2448 }%
2449 \def\XINT_div_I_dN #1.%
2450 {%
2451 \expandafter\XINT_div_I_dP\the\numexpr #1-\xint_c_i.%
2452 }%
2453 \def\XINT_div_I_db #1.#2#3% #1=q=un chiffre, #2=alpha, #3=B
2454 {%
2455 \expandafter\XINT_div_I_dc\expandafter
2456 {\romannumeral0\expandafter\XINT_div_sub_xp xp\expandafter
2457 {\romannumeral0\xintreverseorder{#2}}}%
2458 {\romannumeral0\XINT_mul_Mr {#1}#3\Z\Z\Z }}%
2459 #1{#2}{#3}%
2460 }%
2461 \def\XINT_div_I_dc #1#2%
2462 {%
2463 \if-#1% s'arranger pour que si négatif on ait renvoyé alpha=-.
2464 \expandafter\xint_firstoftwo
2465 \else\expandafter\xint_secondoftwo\fi
2466 {\expandafter\XINT_div_I_dP\the\numexpr #2-\xint_c_i.}%
2467 {\XINT_div_I_e {#1}#2}%
2468 }%

alpha,q,ancien alpha,B, q0->1nouveauq.alpha, L, K, {x'y},x, alpha', BQ«c»

2469 \def\XINT_div_I_e #1#2#3#4#5%
2470 {%
2471 \expandafter\XINT_div_I_f \the\numexpr \xint_c_x^iv+#2+#5{#1}%
2472 }%

q.alpha, B, q0, L, K, {x'y},x, alpha'BQ«c» (intercepter q=0?) -> 1nouveauq.nouvel
alpha, L, K, {x'y}, x, alpha',BQ«c»

2473 \def\XINT_div_I_dP #1.#2#3#4%
2474 {%
2475 \expandafter \XINT_div_I_f \the\numexpr \xint_c_x^iv+#1+#4\expandafter
2476 {\romannumeral0\expandafter\XINT_div_sub_xp xp\expandafter
2477 {\romannumeral0\xintreverseorder{#2}}}%
2478 {\romannumeral0\XINT_mul_Mr {#1}#3\Z\Z\Z }}%
2479 }%

1#1#2#3#4=nouveau q, nouvel alpha, L, K, {x'y},x,alpha', BQ«c»

```

### 36 Package *xint* implementation

```

2480 \def\XINT_div_I_f #1#2#3#4{\XINT_div_I_g {#1#2#3#4}}%
      #1=q,#2=nouvel alpha,#3=L, #4=K, #5={x'y}, #6=x, #7= alpha',#8=B, #9=Q«c» ->
      {x'y}alpha.alpha'.{{x'y}xKL}B{Qq}«c»

2481 \def\XINT_div_I_g #1#2#3#4#5#6#7#8#9%
2482 {%
2483     \ifnum#3=#4
2484         \expandafter\XINT_div_III_ab
2485     \else
2486         \expandafter\XINT_div_I_h
2487     \fi
2488     {#5}#2.#7.{{#5}{#6}{#4}{#3}}{#8}{#9#1}%
2489 }%

      {x'y}alpha.alpha'.{{x'y}xKL}B{Qq}«c» -> R sans leading zeros.{Qq}«c»

2490 \def\XINT_div_III_ab #1#2.#3.#4#5%
2491 {%
2492     \expandafter\XINT_div_III_b
2493     \romannumeral0\XINT_cuz_loop #2#3\W\W\W\W\W\W\W\Z.%
2494 }%

      #1={x'y}alpha.#2#3#4#5#6=reste de A. #7={{x'y},x,K,L},#8=B,nouveauQ«c» devient
      {x'y},alpha sur K+4 chiffres.B, {{x'y},x,K,L}, #6= nouvel alpha',B,nouveauQ«c»

2495 \def\XINT_div_I_h #1.#2#3#4#5#6.#7#8%
2496 {%
2497     \XINT_div_II_b #1#2#3#4#5.{#8}{#7}{#6}{#8}%
2498 }%

      {x'y}alpha.B, {{x'y},x,K,L}, nouveau alpha',B, Q«c» On intercepte la situation
      avec alpha débutant par 0000 qui est la seule qui pourrait donner un q1 nul. Donc
      q1 est non nul et la soustraction spéciale recevra un q1*B de longueur K ou K+4 et
      jamais 0000. Ensuite un q2 éventuel s'il est calculé est nécessairement non nul
      lui aussi. Comme dans la phase I on a aussi intercepté un q nul, la soustraction
      spéciale ne reçoit donc jamais un qB nul. Note: j'ai testé plusieurs fois que ma
      technique de gob_til_zeros est plus rapide que d'utiliser un \ifnum

2499 \def\XINT_div_II_b #1#2#3#4#5#6#7#8#9%
2500 {%
2501     \xint_gob_til_zeros_iv #2#3#4#5\XINT_div_II_skipc 0000%
2502     \XINT_div_II_c #1{#2#3#4#5}{#6#7#8#9}%
2503 }%

      x'y{0000}{4chiffres}reste de alpha.#6=B,#7={{x'y},x,K,L}, alpha',B, Q«c» ->
      {x'y}x,K,L (à diminuer de 4), {alpha sur K}B{q1=0000}{alpha'}B,Q«c»

2504 \def\XINT_div_II_skipc 0000\XINT_div_II_c #1#2#3#4#5.#6#7%
2505 {%
2506     \XINT_div_II_k #7{#4#5}{#6}{0000}%
2507 }%

```

```

x'ya->1qx'alpha.B, {{x'y},x,K,L}, nouveau alpha',B, Q«c»

2508 \def\XINT_div_II_c #1#2#3#4%
2509 {%
2510     \expandafter\XINT_div_II_d\the\numexpr (#3#4+#2)/#1+\xint_c_ixixixix\relax
2511     {#1}{#2}{#3#4}%
2512 }%

1 suivi de q1 sur quatre chiffres, #5=x', #6=y, #7=alpha.#8=B, {{x'y},x,K,L},
alpha', B, Q«c» --> nouvel alpha.x',y,B,q1,{{x'y},x,K,L}, alpha', B, Q«c»

2513 \def\XINT_div_II_d 1#1#2#3#4#5#6#7.#8%
2514 {%
2515     \expandafter\XINT_div_II_e
2516     \romannumeral0\expandafter\XINT_div_sub_xp\expandafter
2517     {\romannumeral0\xintreverseorder{#7}}%
2518     {\romannumeral0\XINT_mul_Mr {#1#2#3#4}#8\Z\Z\Z\Z }.%
2519     {#5}{#6}{#8}{#1#2#3#4}%
2520 }%

alpha.x',y,B,q1, {{x'y},x,K,L}, alpha', B, Q«c»

2521 \def\XINT_div_II_e #1#2#3#4%
2522 {%
2523     \xint_gob_til_zeros_iv #1#2#3#4\XINT_div_II_skipf 0000%
2524     \XINT_div_II_f #1#2#3#4%
2525 }%

0000alpha sur K chiffres.#2=x',#3=y,#4=B,#5=q1, #6={{x'y},x,K,L}, #7=alpha',BQ«c»
-> {x'y}x,K,L (à diminuer de 4), {alpha sur K}B{q1}{alpha'}BQ«c»

2526 \def\XINT_div_II_skipf 0000\XINT_div_II_f 0000#1.#2#3#4#5#6%
2527 {%
2528     \XINT_div_II_k #6{#1}{#4}{#5}%
2529 }%

a1 (huit chiffres), alpha (sur K+4), x', y, B, q1, {{x'y},x,K,L}, alpha', B,Q«c»

2530 \def\XINT_div_II_f #1#2#3#4#5#6#7#8#9.%
2531 {%
2532     \XINT_div_II_fa {#1#2#3#4#5#6#7#8}{#1#2#3#4#5#6#7#8#9}%
2533 }%
2534 \def\XINT_div_II_fa #1#2#3#4%
2535 {%
2536     \expandafter\XINT_div_II_g\expandafter
2537     {\the\numexpr (#1+#4)/#3-\xint_c_i}{#2}%
2538 }%

#1=q, #2=alpha (K+4), #3=B, #4=q1, {{x'y},x,K,L}, alpha', BQ«c» -> 1 puis nouveau
q sur 4 chiffres, nouvel alpha sur K chiffres, B, {{x'y},x,K,L}, alpha',BQ«c»

```

```

2539 \def\XINT_div_II_g #1#2#3#4%
2540 {%
2541   \expandafter \XINT_div_II_h
2542   \the\numexpr #4+#1+\xint_c_x^iv\expandafter\expandafter\expandafter
2543   {\expandafter\xint_gobble_iv
2544   \romannumeral0\expandafter\XINT_div_sub_xpxp\expandafter
2545   {\romannumeral0\xintreverseorder{#2}}}%
2546   {\romannumeral0\XINT_mul_Mr {#1}{#3\Z\Z\Z\Z } }{#3}%
2547 }%

1 puis nouveau q sur 4 chiffres, #5=nouvel alpha sur K chiffres, #6=B, #7={{x'y},x,K,L}
avec L à ajuster, alpha', BQ«c» -> {x'y}x,K,L à diminuer de 4, {alpha}B{q}, al-
pha', BQ«c»

2548 \def\XINT_div_II_h 1#1#2#3#4#5#6#7%
2549 {%
2550   \XINT_div_II_k #7{#5}{#6}{#1#2#3#4}%
2551 }%

{x'y}x,K,L à diminuer de 4, alpha, B{q}alpha',BQ«c» ->nouveau L.K,x',y,x,alpha.B,q,alpha',B,Q«c»
->{LK{x'y}x},x,a,alpha.B,q,alpha',B,Q«c»

2552 \def\XINT_div_II_k #1#2#3#4#5%
2553 {%
2554   \expandafter\XINT_div_II_l \the\numexpr #4-\xint_c_iv.{#3}#1{#2}#5.%
2555 }%
2556 \def\XINT_div_II_l #1.#2#3#4#5#6#7#8#9%
2557 {%
2558   \XINT_div_II_m {{#1}{#2}{{#3}{#4}}{#5}}{#5}{#6#7#8#9}#6#7#8#9%
2559 }%

{LK{x'y}x},x,a,alpha.B{q}alpha'BQ -> a, x, alpha, B, q, L, K, {x'y}, x, alpha',
BQ«c»

2560 \def\XINT_div_II_m #1#2#3#4.#5#6%
2561 {%
2562   \XINT_div_I_a {#3}{#2}{#4}{#5}{#6}#1%
2563 }%

L, K, A, y, {}, x, {}, «c»->A.{yx}L{ }«c» Comme ici K=4, dans la phase I on n'a pas
besoin de alpha, car a = alpha. De plus on a maintenu B dans l'ordre qui est donc la
même chose que x. Par ailleurs la phase I est simplifiée, il s'agit simplement de
la division euclidienne de a par x, et de plus on n'a à la faire qu'une unique fois
et ensuite la phase II peut boucler sur elle-même au lieu de revenir en phase I,
par conséquent il n'y a pas non plus de q0 ici. Enfin, le y est (x/2) pas ((x+1)/2)
il n'y a pas de x'=x+1

2564 \def\XINT_div_little_b #1#2#3#4#5#6#7%
2565 {%
2566   \XINT_div_little_c #3.{{#4}{#6}}{#1}%
2567 }%

```

### 36 Package *xint* implementation

#1#2#3#4=a, #5=alpha'=reste de A.#6={yx}, #7=L, «c» -> a, y, x, L, alpha'=reste de A, «c».

```
2568 \def\XINT_div_little_c #1#2#3#4#5.#6#7%
2569 {%
2570   \XINT_div_littleI_a {#1#2#3#4}#6{#7}{#5}%
2571 }%
```

a, y, x, L, alpha', «c» On calcule ici (contrairement à la phase I générale) le vrai quotient euclidien de a par x=B, c'est donc un chiffre de 0 à 9. De plus on n'a à faire cela qu'une unique fois.

```
2572 \def\XINT_div_littleI_a #1#2#3%
2573 {%
2574   \expandafter\XINT_div_littleI_b
2575   \the\numexpr (#1+#2)/#3-\xint_c_i{#1}{#2}{#3}%
2576 }%
```

On intercepte quotient nul: [est-ce vraiment utile? ou n'est-ce pas plutôt une perte de temps en moyenne? il faudrait tester] q=0#1=a, #2=y, x, L, alpha', «c» -> II\_a avec L{alpha}alpha'.{yx}{0000}«c». Et en cas de quotient non nul on procède avec littleI\_c avec #1=q, #2=a, #3=y, #4=x -> {nouvel alpha sur 4 chiffres}q{yx},L,alpha',«c».

```
2577 \def\XINT_div_littleI_b #1%
2578 {%
2579   \xint_gob_til_zero #1\XINT_div_littleI_skip 0\XINT_div_littleI_c #1%
2580 }%
2581 \def\XINT_div_littleI_skip 0\XINT_div_littleI_c 0#1#2#3#4#5%
2582   {\XINT_div_littleII_a {#4}{#1}#5.{#2}{#3}{0000}}%
2583 \def\XINT_div_littleI_c #1#2#3#4%
2584 {%
2585   \expandafter\expandafter\expandafter\XINT_div_littleI_e
2586   \expandafter\expandafter\expandafter
2587   {\expandafter\xint_gobble_i\the\numexpr \xint_c_x^iv+#2-#1*#4}#1{#3}{#4}}%
2588 }%
```

#1=nouvel alpha sur 4 chiffres#2=q,#3={yx}, #4=L, #5=alpha', «c» -> L{alpha}alpha'.{yx}{000q}«c» point d'entrée de la boucle principale

```
2589 \def\XINT_div_littleI_e #1#2#3#4#5%
2590   {\XINT_div_littleII_a {#4}{#1}#5.{#3}{000#2}}%
```

L{alpha}alpha'.{yx}Q«c» et c'est là qu'on boucle

```
2591 \def\XINT_div_littleII_a #1%
2592 {%
2593   \ifnum#1=\xint_c_iv
2594     \expandafter\XINT_div_littleIII_ab
2595   \else
```

```

2596      \expandafter\XINT_div_littleII_b
2597      \fi {#1}%
2598 }%

L{alpha}alpha'.{yx}Q«c» -> (en fait #3 est vide normalement ici) R sans leading
zeros.Q«c»

2599 \def\XINT_div_littleIII_ab #1#2#3.#4%
2600 {%
2601     \expandafter\XINT_div_III_b\the\numexpr #2#3.%
2602 }%

L{alpha}alpha'.{yx}Q«c». On diminue L de quatre, comme cela c'est fait.

2603 \def\XINT_div_littleII_b #1%
2604 {%
2605     \expandafter\XINT_div_littleII_c\expandafter {\the\numexpr #1-\xint_c_iv}%
2606 }%

{nouveauL}{alpha}alpha'.{yx}Q«c». On prélève 4 chiffres de alpha' -> {nouvel
alpha sur huit chiffres}yx{nouveau L}{nouvel alpha'}Q«c». Regarder si l'ancien
alpha était 0000 n'avancerait à rien car obligerait à refaire une chose comme la
phase I, donc on ne perd pas de temps avec ça, on reste en permanence en phase II.

2607 \def\XINT_div_littleII_c #1#2#3#4#5#6#7.#8%
2608 {%
2609     \XINT_div_littleII_d {#2#3#4#5#6}#8{#1}{#7}%
2610 }%
2611 \def\XINT_div_littleII_d #1#2#3%
2612 {%
2613     \expandafter\XINT_div_littleII_e\the\numexpr (#1+#2)/#3+\xint_c_ixixixix.%
2614     {#1}{#2}{#3}%
2615 }%

1 suivi de #1=q1 sur quatre chiffres.#2=alpha, #3=y, #4=x, L, alpha', Q«c» -->
nouvel alpha sur 4.{q1}{yx},L,alpha', Q«c»

2616 \def\XINT_div_littleII_e 1#1.#2#3#4%
2617 {%
2618     \expandafter\expandafter\expandafter\XINT_div_littleII_f
2619     \expandafter\xint_gobble_i\the\numexpr \xint_c_x^iv+#2-#1*#4.%
2620     {#1}{#3}{#4}%
2621 }%

alpha.q,{yx},L,alpha',Q«c»->L{alpha}alpha'.{yx}{q}Q«c»

2622 \def\XINT_div_littleII_f #1.#2#3#4#5#6%
2623 {%
2624     \XINT_div_littleII_a {#4}{#1}#5.{#3}{#6#2}%
2625 }%

```

La soustraction spéciale. Dans 1.09j, elle fait  $A - qB$ , pour  $A$  (en fait  $\alpha$  dans mes dénominations des commentaires du code) et  $qB$  chacun de longueur  $K$  ou  $K+4$ , avec  $K$  au moins huit multiple de quatre,  $qB$  a ses quatre chiffres significatifs (qui sont à droite) non nuls. Si  $A - qB < 0$  il suffit de renvoyer  $-$ , le résultat n'importe pas. On est sûr que  $qB$  est non nul. On le met dans cette version en premier pour tester plus facilement le cas avec  $qB$  de longueur  $K+4$  et  $A$  de longueur seulement  $K$ . Lorsque la longueur de  $qB$  est inférieure ou égale à celle de  $A$ , on va jusqu'à la fin de  $A$  et donc c'est la retenue finale qui décide du cas négatif éventuel. Le résultat non négatif est toujours donc renvoyé avec la même longueur que  $A$ , et il est dans l'ordre. J'ai fait une implémentation des phases I et II en maintenant  $\alpha$  toujours à l'envers afin d'éviter le reverse order systématique fait sur  $A$  (ou plutôt  $\alpha$ ), mais alors il fallait que la soustraction ici s'arrange pour repérer les huit chiffres les plus significatifs, au final ce n'était pas plus rapide, et même pénalisant pour de gros inputs. Dans les versions 1.09i et antérieures (en fait je pense qu'ici rien quasiment n'avait bougé depuis la première implémentation), la soustraction spéciale n'était pratiquée que dans des cas avec certainement  $A - qB$  positif ou nul. De plus on n'excluait pas  $q=0$ , donc il fallait aussi faire un éventuel reverseorder sur ce qui était encore non traité. Les cas avec  $q=0$  sont maintenant interceptés en amont et comme  $A$  et  $qB$  ont toujours quasiment la même longueur on ne s'embarrasse pas de complications pour la fin.

```

2626 \def\XINT_div_sub_xpxp #1#2% #1= $\alpha$  déjà renversé, #2 se développe en  $qB$ 
2627 {%
2628   \expandafter\XINT_div_sub_xpxp_b #2\W\X\Y\Z #1\W\X\Y\Z
2629 }%
2630 \def\XINT_div_sub_xpxp_b
2631 {%
2632   \XINT_div_sub_A 1}%
2633 }%
2634 \def\XINT_div_sub_A #1#2#3#4#5#6%
2635 {%
2636   \xint_gob_til_W #3\xint_div_sub_az\W
2637   \XINT_div_sub_B #1{#3#4#5#6}{#2}%
2638 }%
2639 \def\XINT_div_sub_B #1#2#3#4\W\X\Y\Z #5#6#7#8%
2640 {%
2641   \xint_gob_til_W #5\xint_div_sub_bz\W
2642   \XINT_div_sub_onestep #1#2{#8#7#6#5}{#3}#4\W\X\Y\Z
2643 }%
2644 \def\XINT_div_sub_onestep #1#2#3#4#5#6%
2645 {%
2646   \expandafter\XINT_div_sub_backtoA
2647   \the\numexpr 11#6-#5#4#3#2+#1-\xint_c_i.%
2648 }%
2649 \def\XINT_div_sub_backtoA #1#2#3.#4%
2650 {%
2651   \XINT_div_sub_A #2{#3#4}%
2652 }%
```

si on arrive en sub\_bz c'est que qB était de longueur K+4 et A seulement de longueur K, le résultat est donc < 0, renvoyer juste -

2653 \def\xint\_div\_sub\_bz\W\XINT\_div\_sub\_onestep #1\Z { -}%

si on arrive en sub\_az c'est que qB était de longueur inférieure ou égale à celle de A, donc on continue jusqu'à la fin de A, et on vérifiera la retenue à la fin.

2654 \def\xint\_div\_sub\_az\W\XINT\_div\_sub\_B #1#2{\XINT\_div\_sub\_C #1}%

2655 \def\XINT\_div\_sub\_C #1#2#3#4#5#6%

2656 {%

2657 \xint\_gob\_til\_W #3\xint\_div\_sub\_cz\W

2658 \XINT\_div\_sub\_C\_onestep #1{#6#5#4#3}{#2}%

2659 }%

2660 \def\XINT\_div\_sub\_C\_onestep #1#2%

2661 {%

2662 \expandafter\XINT\_div\_sub\_backtoC \the\numexpr 11#2+#1-\xint\_c\_i.%

2663 }%

2664 \def\XINT\_div\_sub\_backtoC #1#2#3.#4%

2665 {%

2666 \XINT\_div\_sub\_C #2{#3#4}%

2667 }%

une fois arrivé en sub\_cz on teste la retenue pour voir si le résultat final est en fait négatif, dans ce cas on renvoie seulement -

2668 \def\xint\_div\_sub\_cz\W\XINT\_div\_sub\_C\_onestep #1#2%

2669 {%

2670 \if#10% retenue

2671 \expandafter\xint\_div\_sub\_neg

2672 \else\expandafter\xint\_div\_sub\_ok

2673 \fi

2674 }%

2675 \def\xint\_div\_sub\_neg #1{ -}%

2676 \def\xint\_div\_sub\_ok #1{ #1}%

-----  
-----

DECIMAL OPERATIONS: FIRST DIGIT, LASTDIGIT, ODDNESS, MULTIPLICATION BY TEN, QUOTIENT BY TEN, QUOTIENT OR MULTIPLICATION BY POWER OF TEN, SPLIT OPERATION.

### 36.49 \xintFDg

FIRST DIGIT. Code simplified in 1.05. And prepared for redefinition by xintfrac to parse through \xintNum. Version 1.09a inserts the \xintnum already here.

2677 \def\xintiifDg {\romannumeral0\xintiifdg }%

2678 \def\xintiifdg #1%

2679 {%

```

2680 \expandafter\XINT_fdg \romannumeral-‘0#1\W\Z
2681 }%
2682 \def\xintFDg {\romannumeral0\xintfdg }%
2683 \def\xintfdg #1%
2684 {%
2685 \expandafter\XINT_fdg \romannumeral0\xintnum{#1}\W\Z
2686 }%
2687 \def\XINT_FDg #1{\romannumeral0\XINT_fdg #1\W\Z }%
2688 \def\XINT_fdg #1#2#3\Z
2689 {%
2690 \xint_UDzerominusfork
2691 #1-{ 0}% zero
2692 0#1{ #2}% negative
2693 0-{ #1}% positive
2694 \krof
2695 }%

```

### 36.50 \xintLDg

LAST DIGIT. Simplified in 1.05. And prepared for extension by xintfrac to parse through \xintNum. Release 1.09a adds the \xintnum already here, and this propagates to \xintOdd, etc... 1.09e The \xintiLDg is for defining \xintiiOdd which is used once (currently) elsewhere .

```

2696 \def\xintiLDg {\romannumeral0\xintiildg }%
2697 \def\xintiildg #1%
2698 {%
2699 \expandafter\XINT_ldg\expandafter {\romannumeral-‘0#1}%
2700 }%
2701 \def\xintLDg {\romannumeral0\xintldg }%
2702 \def\xintldg #1%
2703 {%
2704 \expandafter\XINT_ldg\expandafter {\romannumeral0\xintnum{#1}}%
2705 }%
2706 \def\XINT_LDg #1{\romannumeral0\XINT_ldg {#1}}%
2707 \def\XINT_ldg #1%
2708 {%
2709 \expandafter\XINT_ldg_\romannumeral0\xintreverseorder {#1}\Z
2710 }%
2711 \def\XINT_ldg_ #1#2\Z{ #1}%

```

### 36.51 \xintMON, \xintMMON

MINUS ONE TO THE POWER N and  $(-1)^{N-1}$

```

2712 \def\xintiimon {\romannumeral0\xintiimon }%
2713 \def\xintiimon #1%
2714 {%

```

```

2715 \ifodd\xintiLDg {#1}
2716 \xint_afterfi{ -1}%
2717 \else
2718 \xint_afterfi{ 1}%
2719 \fi
2720 }%
2721 \def\xintiMMON {\romannumeral0\xintiimmon }%
2722 \def\xintiimmon #1%
2723 {%
2724 \ifodd\xintiLDg {#1}
2725 \xint_afterfi{ 1}%
2726 \else
2727 \xint_afterfi{ -1}%
2728 \fi
2729 }%
2730 \def\xintMON {\romannumeral0\xintmon }%
2731 \def\xintmon #1%
2732 {%
2733 \ifodd\xintLDg {#1}
2734 \xint_afterfi{ -1}%
2735 \else
2736 \xint_afterfi{ 1}%
2737 \fi
2738 }%
2739 \def\xintMMON {\romannumeral0\xintmmon }%
2740 \def\xintmmon #1%
2741 {%
2742 \ifodd\xintLDg {#1}
2743 \xint_afterfi{ 1}%
2744 \else
2745 \xint_afterfi{ -1}%
2746 \fi
2747 }%

```

### 36.52 \xintOdd

1.05 has \xintiOdd, whereas \xintOdd parses through \xintNum. Inadvertently, 1.09a redefined \xintiLDg so \xintiOdd also parsed through \xintNum. Anyway, having a \xintOdd and a \xintiOdd was silly. Removed in 1.09f

```

2748 \def\xintiOdd {\romannumeral0\xintiiodd }%
2749 \def\xintiiodd #1%
2750 {%
2751 \ifodd\xintiLDg{#1}
2752 \xint_afterfi{ 1}%
2753 \else
2754 \xint_afterfi{ 0}%
2755 \fi
2756 }%

```

```

2757 \def\xintOdd {\romannumeral0\xintodd }%
2758 \def\xintodd #1%
2759 {%
2760   \ifodd\xintLDg{#1}
2761     \xint_afterfi{ 1}%
2762   \else
2763     \xint_afterfi{ 0}%
2764   \fi
2765 }%

```

### 36.53 \xintDSL

DECIMAL SHIFT LEFT (=MULTIPLICATION PAR 10)

```

2766 \def\xintDSL {\romannumeral0\xintdsl }%
2767 \def\xintdsl #1%
2768 {%
2769   \expandafter\XINT_dsl \romannumeral-‘0#1\Z
2770 }%
2771 \def\XINT_DSL #1{\romannumeral0\XINT_dsl #1\Z }%
2772 \def\XINT_dsl #1%
2773 {%
2774   \xint_gob_til_zero #1\xint_dsl_zero 0\XINT_dsl_ #1%
2775 }%
2776 \def\xint_dsl_zero 0\XINT_dsl_ 0#1\Z { 0}%
2777 \def\XINT_dsl_ #1\Z { #10}%

```

### 36.54 \xintDSR

DECIMAL SHIFT RIGHT (=DIVISION PAR 10). Release 1.06b which replaced all @’s by underscores left undefined the \xint\_minus used in \XINT\_dsr\_b, and this bug was fixed only later in release 1.09b

```

2778 \def\xintDSR {\romannumeral0\xintdsr }%
2779 \def\xintdsr #1%
2780 {%
2781   \expandafter\XINT_dsr_a\expandafter {\romannumeral-‘0#1}\W\Z
2782 }%
2783 \def\XINT_DSR #1{\romannumeral0\XINT_dsr_a {#1}\W\Z }%
2784 \def\XINT_dsr_a
2785 {%
2786   \expandafter\XINT_dsr_b\romannumeral0\xintreverseorder
2787 }%
2788 \def\XINT_dsr_b #1#2#3\Z
2789 {%
2790   \xint_gob_til_W #2\xint_dsr_onedigit\W
2791   \xint_gob_til_minus #2\xint_dsr_onedigit-%
2792   \expandafter\XINT_dsr_remove

```

```

2793 \romannumeral0\xintreverseorder {#2#3}%
2794 }%
2795 \def\xint_dsr_onedigit #1\xintreverseorder #2{ 0}%
2796 \def\XINT_dsr_remove #1\W { }%

```

### 36.55 \xintDSH, \xintDSHr

DECIMAL SHIFTS \xintDSH {x}{A}

si  $x \leq 0$ , fait  $A \rightarrow A.10^{|x|}$ . v1.03 corrige l'oversight pour  $A=0$ .

si  $x > 0$ , et  $A \geq 0$ , fait  $A \rightarrow \text{quo}(A, 10^x)$

si  $x > 0$ , et  $A < 0$ , fait  $A \rightarrow -\text{quo}(-A, 10^x)$

(donc pour  $x > 0$  c'est comme DSR itéré  $x$  fois)

\xintDSHr donne le 'reste' (si  $x \leq 0$  donne zéro).

Release 1.06 now feeds  $x$  to a \numexpr first. I will have to revise this code at some point.

```

2797 \def\xintDSHr {\romannumeral0\xintdshr }%
2798 \def\xintdshr #1%
2799 {%
2800   \expandafter\XINT_dshr_checkxpositive \the\numexpr #1\relax\Z
2801 }%
2802 \def\XINT_dshr_checkxpositive #1%
2803 {%
2804   \xint_UDzerominusfork
2805   0#1\XINT_dshr_xzeroorneg
2806   #1-\XINT_dshr_xzeroorneg
2807   0-\XINT_dshr_xpositive
2808   \krof #1%
2809 }%
2810 \def\XINT_dshr_xzeroorneg #1\Z #2{ 0}%
2811 \def\XINT_dshr_xpositive #1\Z
2812 {%
2813   \expandafter\xint_secondoftwo_thenstop\romannumeral0\xintdsx {#1}%
2814 }%
2815 \def\xintDSH {\romannumeral0\xintdsh }%
2816 \def\xintdsh #1#2%
2817 {%
2818   \expandafter\xint_dsh\expandafter {\romannumeral-0#2}{#1}%
2819 }%
2820 \def\xint_dsh #1#2%
2821 {%
2822   \expandafter\XINT_dsh_checksignx \the\numexpr #2\relax\Z {#1}%
2823 }%
2824 \def\XINT_dsh_checksignx #1%
2825 {%
2826   \xint_UDzerominusfork
2827   #1-\XINT_dsh_xiszero
2828   0#1\XINT_dsx_xisNeg_checkA      % on passe direct dans DSx
2829   0-\XINT_dsh_xisPos #1}%

```

```

2830 \krof
2831 }%
2832 \def\XINT_dsh_xiszero #1\Z #2{ #2}%
2833 \def\XINT_dsh_xisPos #1\Z #2%
2834 {%
2835 \expandafter\xint_firstoftwo_thenstop
2836 \romannumeral0\XINT_dsx_checksiga #2\Z {#1}% via DSx
2837 }%

```

### 36.56 \xintDSx

Je fais cette routine pour la version 1.01, après modification de \xintDecSplit. Dorénavant \xintDSx fera appel à \xintDecSplit et de même \xintDSH fera appel à \xintDSx. J'ai donc supprimé entièrement l'ancien code de \xintDSH et re-écrit entièrement celui de \xintDecSplit pour  $x$  positif.

--> Attention le cas  $x=0$  est traité dans la même catégorie que  $x > 0$  <--  
 si  $x < 0$ , fait  $A \rightarrow A \cdot 10^{|x|}$   
 si  $x \geq 0$ , et  $A \geq 0$ , fait  $A \rightarrow \{ \text{quo}(A, 10^x) \} \{ \text{rem}(A, 10^x) \}$   
 si  $x \geq 0$ , et  $A < 0$ , d'abord on calcule  $\{ \text{quo}(-A, 10^x) \} \{ \text{rem}(-A, 10^x) \}$   
 puis, si le premier n'est pas nul on lui donne le signe -  
 si le premier est nul on donne le signe - au second.

On peut donc toujours reconstituer l'original  $A$  par  $10^x Q \pm R$  où il faut prendre le signe plus si  $Q$  est positif ou nul et le signe moins si  $Q$  est strictement négatif.

Release 1.06 has a faster and more compactly coded \XINT\_dsx\_zeroloop. Also,  $x$  is now given to a \numexpr. The earlier code should be then simplified, but I leave as is for the time being.

Release 1.07 modified the coding of \XINT\_dsx\_zeroloop, to avoid impacting the input stack. Indeed the truncating, rounding, and conversion to float routines all use internally \XINT\_dsx\_zeroloop (via \XINT\_dsx\_addzerosnofuss), and they were thus roughly limited to generating  $N = 8$  times the input save stack size digits. On TL2012 and TL2013, this means  $40000 = 8 \times 5000$  digits. Although generating more than  $40000$  digits is more like a one shot thing, I wanted to open the possibility of outputting tens of thousands of digits to fail, thus I re-organized \XINT\_dsx\_zeroloop.

January 5, 2014: but it is only with the new division implementation of 1.09j and also with its special \xintXTrunc routine that the possibility mentioned in the last paragraph has become a concrete one in terms of computation time.

```

2838 \def\xintDSx {\romannumeral0\xintdsx}%
2839 \def\xintdsx #1#2%
2840 {%
2841 \expandafter\xint_dsx\expandafter {\romannumeral-'0#2}{#1}%
2842 }%
2843 \def\xint_dsx #1#2%
2844 {%
2845 \expandafter\XINT_dsx_checksiga \the\numexpr #2\relax\Z {#1}%
2846 }%
2847 \def\XINT_DSx #1#2{\romannumeral0\XINT_dsx_checksiga #1\Z {#2}}%

```

```

2848 \def\XINT_dsx #1#2{\XINT_dsx_checksignx #1\Z {#2}}%
2849 \def\XINT_dsx_checksignx #1%
2850 {%
2851   \xint_UDzerominusfork
2852   #1-\XINT_dsx_xisZero
2853   0#1\XINT_dsx_xisNeg_checkA
2854   0-{\XINT_dsx_xisPos #1}%
2855   \krof
2856 }%
2857 \def\XINT_dsx_xisZero #1\Z #2{ {#2}{0}}% attention comme x > 0
2858 \def\XINT_dsx_xisNeg_checkA #1\Z #2%
2859 {%
2860   \XINT_dsx_xisNeg_checkA_ #2\Z {#1}%
2861 }%
2862 \def\XINT_dsx_xisNeg_checkA_ #1#2\Z #3%
2863 {%
2864   \xint_gob_til_zero #1\XINT_dsx_xisNeg_Azero 0%
2865   \XINT_dsx_xisNeg_checkx {#3}{#3}{}\Z {#1#2}%
2866 }%
2867 \def\XINT_dsx_xisNeg_Azero #1\Z #2{ 0}%
2868 \def\XINT_dsx_xisNeg_checkx #1%
2869 {%
2870   \ifnum #1>10000000
2871     \xint_afterfi
2872     {\xintError:TooBigDecimalShift
2873     \expandafter\space\expandafter 0\xint_gobble_iv }%
2874   \else
2875     \expandafter \XINT_dsx_zeroloop
2876   \fi
2877 }%
2878 \def\XINT_dsx_addzerosnofuss #1{\XINT_dsx_zeroloop {#1}}\Z }%
2879 \def\XINT_dsx_zeroloop #1#2%
2880 {%
2881   \ifnum #1<\xint_c_ix \XINT_dsx_exita\fi
2882   \expandafter\XINT_dsx_zeroloop\expandafter
2883   {\the\numexpr #1-\xint_c_viii}{#2000000000}%
2884 }%
2885 \def\XINT_dsx_exita\fi\expandafter\XINT_dsx_zeroloop
2886 {%
2887   \fi\expandafter\XINT_dsx_exitb
2888 }%
2889 \def\XINT_dsx_exitb #1#2%
2890 {%
2891   \expandafter\expandafter\expandafter
2892   \XINT_dsx_addzeros\csname xint_gobble_\romannumeral -#1\endcsname #2%
2893 }%
2894 \def\XINT_dsx_addzeros #1\Z #2{ #2#1}%
2895 \def\XINT_dsx_xisPos #1\Z #2%
2896 {%

```

```

2897 \XINT_dsx_checksiga #2\Z {#1}%
2898 }%
2899 \def\XINT_dsx_checksiga #1%
2900 {%
2901 \xint_UDzerominusfork
2902 #1-\XINT_dsx_AisZero
2903 0#1\XINT_dsx_AisNeg
2904 0-{\XINT_dsx_AisPos #1}%
2905 \krof
2906 }%
2907 \def\XINT_dsx_AisZero #1\Z #2{ {0}{0}}%
2908 \def\XINT_dsx_AisNeg #1\Z #2%
2909 {%
2910 \expandafter\XINT_dsx_AisNeg_dosplit_andcheckfirst
2911 \romannumeral0\XINT_split_checksizex {#2}{#1}%
2912 }%
2913 \def\XINT_dsx_AisNeg_dosplit_andcheckfirst #1%
2914 {%
2915 \XINT_dsx_AisNeg_checkiffirstempty #1\Z
2916 }%
2917 \def\XINT_dsx_AisNeg_checkiffirstempty #1%
2918 {%
2919 \xint_gob_til_Z #1\XINT_dsx_AisNeg_finish_zero\Z
2920 \XINT_dsx_AisNeg_finish_notzero #1%
2921 }%
2922 \def\XINT_dsx_AisNeg_finish_zero\Z
2923 \XINT_dsx_AisNeg_finish_notzero\Z #1%
2924 {%
2925 \expandafter\XINT_dsx_end
2926 \expandafter {\romannumeral0\XINT_num {-#1}}{0}%
2927 }%
2928 \def\XINT_dsx_AisNeg_finish_notzero #1\Z #2%
2929 {%
2930 \expandafter\XINT_dsx_end
2931 \expandafter {\romannumeral0\XINT_num {#2}}{-#1}%
2932 }%
2933 \def\XINT_dsx_AisPos #1\Z #2%
2934 {%
2935 \expandafter\XINT_dsx_AisPos_finish
2936 \romannumeral0\XINT_split_checksizex {#2}{#1}%
2937 }%
2938 \def\XINT_dsx_AisPos_finish #1#2%
2939 {%
2940 \expandafter\XINT_dsx_end
2941 \expandafter {\romannumeral0\XINT_num {#2}}%
2942 {\romannumeral0\XINT_num {#1}}%
2943 }%
2944 \edef\XINT_dsx_end #1#2%
2945 {%

```

```

2946 \noexpand\expandafter\space\noexpand\expandafter{#2}{#1}%
2947 }%

```

### 36.57 \xintDecSplit, \xintDecSplitL, \xintDecSplitR

#### DECIMAL SPLIT

The macro `\xintDecSplit {x}{A}` first replaces `A` with `|A|` (\*) This macro cuts the number into two pieces `L` and `R`. The concatenation `LR` always reproduces `|A|`, and `R` may be empty or have leading zeros. The position of the cut is specified by the first argument `x`. If `x` is zero or positive the cut location is `x` slots to the left of the right end of the number. If `x` becomes equal to or larger than the length of the number then `L` becomes empty. If `x` is negative the location of the cut is `|x|` slots to the right of the left end of the number.

(\*) warning: this may change in a future version. Only the behavior for `A` non-negative is guaranteed to remain the same.

v1.05a: `\XINT_split_checksizex` does not compute the length anymore, rather the error will be from a `\numexpr`; but the limit of 999999999 does not make much sense.

v1.06: Improvements in `\XINT_split_fromleft_loop`, `\XINT_split_fromright_loop` and related macros. More readable coding, speed gains. Also, I now feed immediately a `\numexpr` with `x`. Some simplifications should probably be made to the code, which is kept as is for the time being.

1.09e pays attention to the use of `xintiabs` which acquired in 1.09a the `xintnum` overhead. So `xintiabs` rather without that overhead.

```

2948 \def\xintDecSplitL {\romannumeral0\xintdecsplitl }%
2949 \def\xintDecSplitR {\romannumeral0\xintdecsplitr }%
2950 \def\xintdecsplitl
2951 {%
2952   \expandafter\xint_firstoftwo_thenstop
2953   \romannumeral0\xintdecsplit
2954 }%
2955 \def\xintdecsplitr
2956 {%
2957   \expandafter\xint_secondoftwo_thenstop
2958   \romannumeral0\xintdecsplit
2959 }%
2960 \def\xintDecSplit {\romannumeral0\xintdecsplit }%
2961 \def\xintdecsplit #1#2%
2962 {%
2963   \expandafter \xint_split \expandafter
2964   {\romannumeral0\xintiabs {#2}}{#1}%   fait expansion de A
2965 }%
2966 \def\xint_split #1#2%
2967 {%
2968   \expandafter\XINT_split_checksizex\expandafter{\the\numexpr #2}{#1}%
2969 }%
2970 \def\XINT_split_checksizex #1% 999999999 is anyhow very big, could be reduced
2971 {%
2972   \ifnum\numexpr\XINT_Abs{#1}>999999999

```

```

2973     \xint_afterfi {\xintError:TooBigDecimalSplit\XINT_split_bigx }%
2974     \else
2975     \expandafter\XINT_split_xfork
2976     \fi
2977     #1\Z
2978 }%
2979 \def\XINT_split_bigx #1\Z #2%
2980 {%
2981     \ifcase\XINT_cntSgn #1\Z
2982     \or \xint_afterfi { {}{#2}}% positive big x
2983     \else
2984     \xint_afterfi { {}{#2}}% negative big x
2985     \fi
2986 }%
2987 \def\XINT_split_xfork #1%
2988 {%
2989     \xint_UDzerominusfork
2990     #1-\XINT_split_zerosplit
2991     0#1\XINT_split_fromleft
2992     0-\XINT_split_fromright #1}%
2993     \krof
2994 }%
2995 \def\XINT_split_zerosplit #1\Z #2{ {}{#2}}%
2996 \def\XINT_split_fromleft #1\Z #2%
2997 {%
2998     \XINT_split_fromleft_loop {#1}{#2\W\W\W\W\W\W\W\W\Z
2999 }%
3000 \def\XINT_split_fromleft_loop #1%
3001 {%
3002     \ifnum #1<\xint_c_viii\XINT_split_fromleft_exita\fi
3003     \expandafter\XINT_split_fromleft_loop_perhaps\expandafter
3004     {\the\numexpr #1-\xint_c_viii\expandafter}\XINT_split_fromleft_eight
3005 }%
3006 \def\XINT_split_fromleft_eight #1#2#3#4#5#6#7#8#9{#9{#1#2#3#4#5#6#7#8#9}}%
3007 \def\XINT_split_fromleft_loop_perhaps #1#2%
3008 {%
3009     \xint_gob_til_W #2\XINT_split_fromleft_toofar\W
3010     \XINT_split_fromleft_loop {#1}%
3011 }%
3012 \def\XINT_split_fromleft_toofar\W\XINT_split_fromleft_loop #1#2#3\Z
3013 {%
3014     \XINT_split_fromleft_toofar_b #2\Z
3015 }%
3016 \def\XINT_split_fromleft_toofar_b #1\W #2\Z { {}{#1}}%
3017 \def\XINT_split_fromleft_exita\fi
3018     \expandafter\XINT_split_fromleft_loop_perhaps\expandafter #1#2%
3019     {\fi \XINT_split_fromleft_exitb #1}%
3020 \def\XINT_split_fromleft_exitb\the\numexpr #1-\xint_c_viii\expandafter
3021 {%

```

```

3022 \csname XINT_split_fromleft_endsplit_\romannumeral #1\endcsname
3023 }%
3024 \def\XINT_split_fromleft_endsplit_ #1#2\W #3\Z { {#1}{#2}}%
3025 \def\XINT_split_fromleft_endsplit_i #1#2%
3026         {\XINT_split_fromleft_checkiftoofar #2{#1#2}}%
3027 \def\XINT_split_fromleft_endsplit_ii #1#2#3%
3028         {\XINT_split_fromleft_checkiftoofar #3{#1#2#3}}%
3029 \def\XINT_split_fromleft_endsplit_iii #1#2#3#4%
3030         {\XINT_split_fromleft_checkiftoofar #4{#1#2#3#4}}%
3031 \def\XINT_split_fromleft_endsplit_iv #1#2#3#4#5%
3032         {\XINT_split_fromleft_checkiftoofar #5{#1#2#3#4#5}}%
3033 \def\XINT_split_fromleft_endsplit_v #1#2#3#4#5#6%
3034         {\XINT_split_fromleft_checkiftoofar #6{#1#2#3#4#5#6}}%
3035 \def\XINT_split_fromleft_endsplit_vi #1#2#3#4#5#6#7%
3036         {\XINT_split_fromleft_checkiftoofar #7{#1#2#3#4#5#6#7}}%
3037 \def\XINT_split_fromleft_endsplit_vii #1#2#3#4#5#6#7#8%
3038         {\XINT_split_fromleft_checkiftoofar #8{#1#2#3#4#5#6#7#8}}%
3039 \def\XINT_split_fromleft_checkiftoofar #1#2#3\W #4\Z
3040 {%
3041     \xint_gob_til_W #1\XINT_split_fromleft_wenttoofar\W
3042     \space {#2}{#3}%
3043 }%
3044 \def\XINT_split_fromleft_wenttoofar\W\space #1%
3045 {%
3046     \XINT_split_fromleft_wenttoofar_b #1\Z
3047 }%
3048 \def\XINT_split_fromleft_wenttoofar_b #1\W #2\Z { {#1}}%
3049 \def\XINT_split_fromright #1\Z #2%
3050 {%
3051     \expandafter \XINT_split_fromright_a \expandafter
3052     {\romannumeral0\xintreverseorder {#2}}{#1}{#2}%
3053 }%
3054 \def\XINT_split_fromright_a #1#2%
3055 {%
3056     \XINT_split_fromright_loop {#2}{#1\W\W\W\W\W\W\W\W\Z
3057 }%
3058 \def\XINT_split_fromright_loop #1%
3059 {%
3060     \ifnum #1<\xint_c_viii\XINT_split_fromright_exita\fi
3061     \expandafter\XINT_split_fromright_loop_perhaps\expandafter
3062     {\the\numexpr #1-\xint_c_viii\expandafter }\XINT_split_fromright_eight
3063 }%
3064 \def\XINT_split_fromright_eight #1#2#3#4#5#6#7#8#9{#9{#9#8#7#6#5#4#3#2#1}}%
3065 \def\XINT_split_fromright_loop_perhaps #1#2%
3066 {%
3067     \xint_gob_til_W #2\XINT_split_fromright_toofar\W
3068     \XINT_split_fromright_loop {#1}%
3069 }%
3070 \def\XINT_split_fromright_toofar\W\XINT_split_fromright_loop #1#2#3\Z { {}}%

```

```

3071 \def\XINT_split_fromright_exita\fi
3072   \expandafter\XINT_split_fromright_loop_perhaps\expandafter #1#2%
3073   {\fi \XINT_split_fromright_exitb #1}%
3074 \def\XINT_split_fromright_exitb\the\numexpr #1-\xint_c_viii\expandafter
3075 {%
3076   \csname XINT_split_fromright_endsplit_\romannumeral #1\endcsname
3077 }%
3078 \edef\XINT_split_fromright_endsplit_ #1#2\W #3\Z #4%
3079 {%
3080   \noexpand\expandafter\space\noexpand\expandafter
3081   {\noexpand\romannumeral0\noexpand\xintreverseorder {#2}}{#1}%
3082 }%
3083 \def\XINT_split_fromright_endsplit_i #1#2%
3084   {\XINT_split_fromright_checkiftoofar #2{#2#1}}%
3085 \def\XINT_split_fromright_endsplit_ii #1#2#3%
3086   {\XINT_split_fromright_checkiftoofar #3{#3#2#1}}%
3087 \def\XINT_split_fromright_endsplit_iii #1#2#3#4%
3088   {\XINT_split_fromright_checkiftoofar #4{#4#3#2#1}}%
3089 \def\XINT_split_fromright_endsplit_iv #1#2#3#4#5%
3090   {\XINT_split_fromright_checkiftoofar #5{#5#4#3#2#1}}%
3091 \def\XINT_split_fromright_endsplit_v #1#2#3#4#5#6%
3092   {\XINT_split_fromright_checkiftoofar #6{#6#5#4#3#2#1}}%
3093 \def\XINT_split_fromright_endsplit_vi #1#2#3#4#5#6#7%
3094   {\XINT_split_fromright_checkiftoofar #7{#7#6#5#4#3#2#1}}%
3095 \def\XINT_split_fromright_endsplit_vii #1#2#3#4#5#6#7#8%
3096   {\XINT_split_fromright_checkiftoofar #8{#8#7#6#5#4#3#2#1}}%
3097 \def\XINT_split_fromright_checkiftoofar #1%
3098 {%
3099   \xint_gob_til_W #1\XINT_split_fromright_wenttoofar\W
3100   \XINT_split_fromright_endsplit_
3101 }%
3102 \def\XINT_split_fromright_wenttoofar\W\XINT_split_fromright_endsplit_ #1\Z #2%
3103   { {#2}}%

```

### 36.58 \xintDouble

v1.08

```

3104 \def\xintDouble {\romannumeral0\xintdouble }%
3105 \def\xintdouble #1%
3106 {%
3107   \expandafter\XINT_dbl\romannumeral-‘0#1%
3108   \R\R\R\R\R\R\R\Z \W\W\W\W\W\W\W
3109 }%
3110 \def\XINT_dbl #1%
3111 {%
3112   \xint_UDzerominusfork
3113   #1-\XINT_dbl_zero
3114   0#1\XINT_dbl_neg

```

```

3115      0-{\XINT_dbl_pos #1}%
3116      \krof
3117 }%
3118 \def\XINT_dbl_zero #1\Z \W\W\W\W\W\W\W { 0}%
3119 \def\XINT_dbl_neg
3120      {\expandafter\xint_minus_thenstop\romannumeral0\XINT_dbl_pos }%
3121 \def\XINT_dbl_pos
3122 {%
3123      \expandafter\XINT_dbl_a \expandafter{\expandafter}\expandafter 0%
3124      \romannumeral0\XINT_SQ {}%
3125 }%
3126 \def\XINT_dbl_a #1#2#3#4#5#6#7#8#9%
3127 {%
3128      \xint_gob_til_W #9\XINT_dbl_end_a\W
3129      \expandafter\XINT_dbl_b
3130      \the\numexpr \xint_c_x^viii+#2+\xint_c_ii*#9#8#7#6#5#4#3\relax {#1}%
3131 }%
3132 \def\XINT_dbl_b 1#1#2#3#4#5#6#7#8#9%
3133 {%
3134      \XINT_dbl_a {#2#3#4#5#6#7#8#9}{#1}%
3135 }%
3136 \def\XINT_dbl_end_a #1+#2+#3\relax #4%
3137 {%
3138      \expandafter\XINT_dbl_end_b #2#4%
3139 }%
3140 \edef\XINT_dbl_end_b #1#2#3#4#5#6#7#8%
3141 {%
3142      \noexpand\expandafter\space\noexpand\the\numexpr #1#2#3#4#5#6#7#8\relax
3143 }%

```

### 36.59 \xintHalf

v1.08

```

3144 \def\xintHalf {\romannumeral0\xinthalft}%
3145 \def\xinthalft #1%
3146 {%
3147      \expandafter\XINT_half\romannumeral-‘0#1%
3148      \R\R\R\R\R\R\R\Z \W\W\W\W\W\W\W
3149 }%
3150 \def\XINT_half #1%
3151 {%
3152      \xint_UDzerominusfork
3153      #1-\XINT_half_zero
3154      0#1\XINT_half_neg
3155      0-{\XINT_half_pos #1}%
3156      \krof
3157 }%
3158 \def\XINT_half_zero #1\Z \W\W\W\W\W\W\W { 0}%

```

```

3159 \def\XINT_half_neg {\expandafter\XINT_opp\romannumeral0\XINT_half_pos }%
3160 \def\XINT_half_pos {\expandafter\XINT_half_a\romannumeral0\XINT_SQ {}}%
3161 \def\XINT_half_a #1#2#3#4#5#6#7#8%
3162 {%
3163   \xint_gob_til_W #8\XINT_half_dont\W
3164   \expandafter\XINT_half_b
3165   \the\numexpr \xint_c_x^viii+\xint_c_v*#7#6#5#4#3#2#1\relax #8%
3166 }%
3167 \edef\XINT_half_dont\W\expandafter\XINT_half_b
3168   \the\numexpr \xint_c_x^viii+\xint_c_v*#1#2#3#4#5#6#7\relax \W\W\W\W\W\W\W
3169 {%
3170   \noexpand\expandafter\space
3171   \noexpand\the\numexpr (#1#2#3#4#5#6#7+\xint_c_i)/\xint_c_ii-\xint_c_i \relax
3172 }%
3173 \def\XINT_half_b 1#1#2#3#4#5#6#7#8%
3174 {%
3175   \XINT_half_c {#2#3#4#5#6#7}{#1}%
3176 }%
3177 \def\XINT_half_c #1#2#3#4#5#6#7#8#9%
3178 {%
3179   \xint_gob_til_W #3\XINT_half_end_a #2\W
3180   \expandafter\XINT_half_d
3181   \the\numexpr \xint_c_x^viii+\xint_c_v*#9#8#7#6#5#4#3+#2\relax {#1}%
3182 }%
3183 \def\XINT_half_d 1#1#2#3#4#5#6#7#8#9%
3184 {%
3185   \XINT_half_c {#2#3#4#5#6#7#8#9}{#1}%
3186 }%
3187 \def\XINT_half_end_a #1\W #2\relax #3%
3188 {%
3189   \xint_gob_til_zero #1\XINT_half_end_b 0\space #1#3%
3190 }%
3191 \edef\XINT_half_end_b 0\space 0#1#2#3#4#5#6#7%
3192 {%
3193   \noexpand\expandafter\space\noexpand\the\numexpr #1#2#3#4#5#6#7\relax
3194 }%

```

### 36.60 \xintDec

v1.08

```

3195 \def\xintDec {\romannumeral0\xintdec }%
3196 \def\xintdec #1%
3197 {%
3198   \expandafter\XINT_dec\romannumeral-'0#1%
3199   \R\R\R\R\R\R\R\R\Z \W\W\W\W\W\W\W\W
3200 }%
3201 \def\XINT_dec #1%
3202 {%

```

```

3203 \xint_UDzerominusfork
3204 #1-\XINT_dec_zero
3205 0#1\XINT_dec_neg
3206 0-{\XINT_dec_pos #1}%
3207 \krof
3208 }%
3209 \def\XINT_dec_zero #1\W\W\W\W\W\W\W\W { -1}%
3210 \def\XINT_dec_neg
3211 {\expandafter\xint_minus_thenstop\romannumeral0\XINT_inc_pos }%
3212 \def\XINT_dec_pos
3213 {%
3214 \expandafter\XINT_dec_a \expandafter{\expandafter}%
3215 \romannumeral0\XINT_OQ {}%
3216 }%
3217 \def\XINT_dec_a #1#2#3#4#5#6#7#8#9%
3218 {%
3219 \expandafter\XINT_dec_b
3220 \the\numexpr 11#9#8#7#6#5#4#3#2-\xint_c_i\relax {#1}%
3221 }%
3222 \def\XINT_dec_b 1#1%
3223 {%
3224 \xint_gob_til_one #1\XINT_dec_A 1\XINT_dec_c
3225 }%
3226 \def\XINT_dec_c #1#2#3#4#5#6#7#8#9{\XINT_dec_a {#1#2#3#4#5#6#7#8#9}}%
3227 \def\XINT_dec_A 1\XINT_dec_c #1#2#3#4#5#6#7#8#9%
3228 {\XINT_dec_B {#1#2#3#4#5#6#7#8#9}}%
3229 \def\XINT_dec_B #1#2\W\W\W\W\W\W\W\W
3230 {%
3231 \expandafter\XINT_dec_cleanup
3232 \romannumeral0\XINT_rord_main {}%#2%
3233 \xint_relax
3234 \xint_bye\xint_bye\xint_bye\xint_bye
3235 \xint_bye\xint_bye\xint_bye\xint_bye
3236 \xint_relax
3237 #1%
3238 }%
3239 \edef\XINT_dec_cleanup #1#2#3#4#5#6#7#8%
3240 {\noexpand\expandafter\space\noexpand\the\numexpr #1#2#3#4#5#6#7#8\relax }%

```

### 36.61 \xintInc

v1.08

```

3241 \def\xintInc {\romannumeral0\xintinc }%
3242 \def\xintinc #1%
3243 {%
3244 \expandafter\XINT_inc\romannumeral-‘0#1%
3245 \R\R\R\R\R\R\R\R\Z \W\W\W\W\W\W\W\W
3246 }%

```

```

3247 \def\XINT_inc #1%
3248 {%
3249   \xint_UDzerominusfork
3250   #1-\XINT_inc_zero
3251   0#1\XINT_inc_neg
3252   0-{\XINT_inc_pos #1}%
3253   \krof
3254 }%
3255 \def\XINT_inc_zero #1\W\W\W\W\W\W\W { 1}%
3256 \def\XINT_inc_neg {\expandafter\XINT_opp\romannumeral0\XINT_dec_pos }%
3257 \def\XINT_inc_pos
3258 {%
3259   \expandafter\XINT_inc_a \expandafter{\expandafter}%
3260   \romannumeral0\XINT_OQ {}%
3261 }%
3262 \def\XINT_inc_a #1#2#3#4#5#6#7#8#9%
3263 {%
3264   \xint_gob_til_W #9\XINT_inc_end\W
3265   \expandafter\XINT_inc_b
3266   \the\numexpr 10#9#8#7#6#5#4#3#2+\xint_c_i\relax {#1}%
3267 }%
3268 \def\XINT_inc_b 1#1%
3269 {%
3270   \xint_gob_til_zero #1\XINT_inc_A 0\XINT_inc_c
3271 }%
3272 \def\XINT_inc_c #1#2#3#4#5#6#7#8#9{\XINT_inc_a {#1#2#3#4#5#6#7#8#9}}%
3273 \def\XINT_inc_A 0\XINT_inc_c #1#2#3#4#5#6#7#8#9%
3274   {\XINT_dec_B {#1#2#3#4#5#6#7#8#9}}%
3275 \def\XINT_inc_end\W #1\relax #2{ 1#2}%

```

### 36.62 \xintiSqrt, \xintiSquareRoot

v1.08. 1.09a uses \xintnum.

Some overhead was added inadvertently in 1.09a to inner routines when \xintiquo and \xintidivision were also promoted to use \xintnum; release 1.09f thus uses \xintiquo and \xintiidivision which avoid this \xintnum overhead.

```

3276 \def\xintiSqrt {\romannumeral0\xintisqrt }%
3277 \def\xintisqrt
3278   {\expandafter\XINT_sqrt_post\romannumeral0\xintisquareroot }%
3279 \def\XINT_sqrt_post #1#2{\XINT_dec_pos #1\R\R\R\R\R\R\R\R\Z
3280   \W\W\W\W\W\W\W }%
3281 \def\xintiSquareRoot {\romannumeral0\xintisquareroot }%
3282 \def\xintisquareroot #1%
3283   {\expandafter\XINT_sqrt_checkin\romannumeral0\xintnum{#1}\Z}%
3284 \def\XINT_sqrt_checkin #1%
3285 {%
3286   \xint_UDzerominusfork
3287   #1-\XINT_sqrt_iszero

```

```

3288      0#1\XINT_sqrt_isneg
3289      0-{\XINT_sqrt #1}%
3290      \krof
3291 }%
3292 \def\XINT_sqrt_iszero #1\Z { 1.}%
3293 \edef\XINT_sqrt_isneg #1\Z {\noexpand\xintError:RootOfNegative\space 1.}%
3294 \def\XINT_sqrt #1\Z
3295 {%
3296     \expandafter\XINT_sqrt_start\expandafter
3297         {\romannumeral0\xintlength {#1}}{#1}%
3298 }%
3299 \def\XINT_sqrt_start #1%
3300 {%
3301     \ifnum #1<\xint_c_x
3302         \expandafter\XINT_sqrt_small_a
3303     \else
3304         \expandafter\XINT_sqrt_big_a
3305     \fi
3306     {#1}%
3307 }%
3308 \def\XINT_sqrt_small_a #1{\XINT_sqrt_a {#1}\XINT_sqrt_small_d }%
3309 \def\XINT_sqrt_big_a #1{\XINT_sqrt_a {#1}\XINT_sqrt_big_d }%
3310 \def\XINT_sqrt_a #1%
3311 {%
3312     \ifodd #1
3313         \expandafter\XINT_sqrt_bB
3314     \else
3315         \expandafter\XINT_sqrt_bA
3316     \fi
3317     {#1}%
3318 }%
3319 \def\XINT_sqrt_bA #1#2#3%
3320 {%
3321     \XINT_sqrt_bA_b #3\Z #2{#1}{#3}%
3322 }%
3323 \def\XINT_sqrt_bA_b #1#2#3\Z
3324 {%
3325     \XINT_sqrt_c {#1#2}%
3326 }%
3327 \def\XINT_sqrt_bB #1#2#3%
3328 {%
3329     \XINT_sqrt_bB_b #3\Z #2{#1}{#3}%
3330 }%
3331 \def\XINT_sqrt_bB_b #1#2\Z
3332 {%
3333     \XINT_sqrt_c #1%
3334 }%
3335 \def\XINT_sqrt_c #1#2%
3336 {%

```

```

3337 \expandafter #2\expandafter
3338 {\the\numexpr\ifnum #1>\xint_c_iii
3339 \ifnum #1>\xint_c_viii
3340 \ifnum #1>15 \ifnum #1>24 \ifnum #1>35
3341 \ifnum #1>48 \ifnum #1>63 \ifnum #1>80
3342 10\else 9\fi \else 8\fi \else 7\fi \else 6\fi
3343 \else 5\fi \else 4\fi \else 3\fi \else 2\fi \relax }%
3344 }%
3345 \def\xint_sqrt_small_d #1#2%
3346 {%
3347 \expandafter\xint_sqrt_small_e\expandafter
3348 {\the\numexpr #1\ifcase \numexpr #2/\xint_c_ii-\xint_c_i\relax
3349 \or 0\or 00\or 000\or 0000\fi }%
3350 }%
3351 \def\xint_sqrt_small_e #1#2%
3352 {%
3353 \expandafter\xint_sqrt_small_f\expandafter {\the\numexpr #1*#1-#2}{#1}%
3354 }%
3355 \def\xint_sqrt_small_f #1#2%
3356 {%
3357 \expandafter\xint_sqrt_small_g\expandafter
3358 {\the\numexpr ((#1+#2)/(\xint_c_ii*#2))-\xint_c_i}{#1}{#2}%
3359 }%
3360 \def\xint_sqrt_small_g #1%
3361 {%
3362 \ifnum #1>\xint_c_
3363 \expandafter\xint_sqrt_small_h
3364 \else
3365 \expandafter\xint_sqrt_small_end
3366 \fi
3367 {#1}%
3368 }%
3369 \def\xint_sqrt_small_h #1#2#3%
3370 {%
3371 \expandafter\xint_sqrt_small_f\expandafter
3372 {\the\numexpr #2-\xint_c_ii*#1*#3+#1*#1\expandafter}\expandafter
3373 {\the\numexpr #3-#1}%
3374 }%
3375 \def\xint_sqrt_small_end #1#2#3{ {#3}{#2}}%
3376 \def\xint_sqrt_big_d #1#2%
3377 {%
3378 \ifodd #2
3379 \expandafter\expandafter\expandafter\xint_sqrt_big_eB
3380 \else
3381 \expandafter\expandafter\expandafter\xint_sqrt_big_eA
3382 \fi
3383 \expandafter {\the\numexpr #2/\xint_c_ii }{#1}%
3384 }%
3385 \def\xint_sqrt_big_eA #1#2#3%

```

```

3386 {%
3387   \XINT_sqrt_big_eA_a #3\Z {#2}{#1}{#3}%
3388 }%
3389 \def\XINT_sqrt_big_eA_a #1#2#3#4#5#6#7#8#9\Z
3390 {%
3391   \XINT_sqrt_big_eA_b {#1#2#3#4#5#6#7#8}%
3392 }%
3393 \def\XINT_sqrt_big_eA_b #1#2%
3394 {%
3395   \expandafter\XINT_sqrt_big_f
3396   \romannumeral0\XINT_sqrt_small_e {#2000}{#1}{#1}%
3397 }%
3398 \def\XINT_sqrt_big_eB #1#2#3%
3399 {%
3400   \XINT_sqrt_big_eB_a #3\Z {#2}{#1}{#3}%
3401 }%
3402 \def\XINT_sqrt_big_eB_a #1#2#3#4#5#6#7#8#9%
3403 {%
3404   \XINT_sqrt_big_eB_b {#1#2#3#4#5#6#7#8#9}%
3405 }%
3406 \def\XINT_sqrt_big_eB_b #1#2\Z #3%
3407 {%
3408   \expandafter\XINT_sqrt_big_f
3409   \romannumeral0\XINT_sqrt_small_e {#30000}{#1}{#1}%
3410 }%
3411 \def\XINT_sqrt_big_f #1#2#3#4%
3412 {%
3413   \expandafter\XINT_sqrt_big_f_a\expandafter
3414   {\the\numexpr #2+#3\expandafter}\expandafter
3415   {\romannumeral0\XINT_dsx_addzerosnofuss
3416     {\numexpr #4-\xint_c_iv\relax}{#1}}{#4}%
3417 }%
3418 \def\XINT_sqrt_big_f_a #1#2#3#4%
3419 {%
3420   \expandafter\XINT_sqrt_big_g\expandafter
3421   {\romannumeral0\xintiisub
3422     {\XINT_dsx_addzerosnofuss
3423       {\numexpr \xint_c_ii*#3-\xint_c_viii\relax}{#1}}{#4}}%
3424   {#2}{#3}%
3425 }%
3426 \def\XINT_sqrt_big_g #1#2%
3427 {%
3428   \expandafter\XINT_sqrt_big_j
3429   \romannumeral0\xintiidivision{#1}%
3430   {\romannumeral0\XINT_dbl_pos #2\R\R\R\R\R\R\R\Z \W\W\W\W\W\W\W }{#2}%
3431 }%
3432 \def\XINT_sqrt_big_j #1%
3433 {%
3434   \if0\XINT_Sgn #1\Z

```

```

3435         \expandafter \XINT_sqrt_big_end
3436     \else \expandafter \XINT_sqrt_big_k
3437     \fi {#1}%
3438 }%
3439 \def\XINT_sqrt_big_k #1#2#3%
3440 {%
3441     \expandafter\XINT_sqrt_big_l\expandafter
3442     {\romannumeral0\xintiisub {#3}{#1}}%
3443     {\romannumeral0\xintiisqr {#2}{\xintiisqr {#1}}}%
3444 }%
3445 \def\XINT_sqrt_big_l #1#2%
3446 {%
3447     \expandafter\XINT_sqrt_big_g\expandafter
3448     {#2}{#1}%
3449 }%
3450 \def\XINT_sqrt_big_end #1#2#3#4{ {#3}{#2}}%

```

### 36.63 \xintIsTrue:csv

1.09c. For use by \xinttheboolexpr. (inside \csname, no need for a \romannumeral here). The macros may well be defined already here. I make no advertisement because I have inserted no space parsing in the :csv macros, as they will be used only with privately created comma separated lists, having no space naturally. Nevertheless they exist and can be used.

```

3451 \def\xintIsTrue:csv #1{\expandafter\XINT_istrue:_a\romannumeral-‘0#1,,^}%
3452 \def\XINT_istrue:_a {\XINT_istrue:_b {}}%
3453 \def\XINT_istrue:_b #1#2,%
3454     {\expandafter\XINT_istrue:_c\romannumeral-‘0#2,{#1}}%
3455 \def\XINT_istrue:_c #1{\if #1,\expandafter\XINT:_f
3456     \else\expandafter\XINT_istrue:_d\fi #1}%
3457 \def\XINT_istrue:_d #1,%
3458     {\expandafter\XINT_istrue:_e\romannumeral0\xintisnotzero {#1},}%
3459 \def\XINT_istrue:_e #1,#2{\XINT_istrue:_b {#2,#1}}%
3460 \def\XINT:_f ,#1#2^{\xint_gobble_i #1}%

```

### 36.64 \xintANDof:csv

1.09a. For use by \xintexpr (inside \csname, no need for a \romannumeral here).

```

3461 \def\xintANDof:csv #1{\expandafter\XINT_andof:_a\romannumeral-‘0#1,,^}%
3462 \def\XINT_andof:_a {\expandafter\XINT_andof:_b\romannumeral-‘0}%
3463 \def\XINT_andof:_b #1{\if #1,\expandafter\XINT_andof:_e
3464     \else\expandafter\XINT_andof:_c\fi #1}%
3465 \def\XINT_andof:_c #1,{\xintifTrueAelseB {#1}{\XINT_andof:_a}{\XINT_andof:_no}}%
3466 \def\XINT_andof:_no #1^{}%
3467 \def\XINT_andof:_e #1^{1}% works with empty list

```

**36.65 \xintORof:csv**

1.09a. For use by \xintexpr.

```

3468 \def\xintORof:csv #1{\expandafter\xINT_orof:_a\romannumeral-‘0#1,,^}%
3469 \def\xINT_orof:_a {\expandafter\xINT_orof:_b\romannumeral-‘0}%
3470 \def\xINT_orof:_b #1{\if #1,\expandafter\xINT_orof:_e
3471     \else\expandafter\xINT_orof:_c\fi #1}%
3472 \def\xINT_orof:_c #1,{\xintifTrueAelseB{#1}{\XINT_orof:_yes}{\XINT_orof:_a}}%
3473 \def\xINT_orof:_yes #1^{1}%
3474 \def\xINT_orof:_e #1^{0}% works with empty list

```

**36.66 \xintXORof:csv**

1.09a. For use by \xintexpr (inside a \csname..\endcsname).

```

3475 \def\xintXORof:csv #1{\expandafter\xINT_xorof:_a\expandafter
3476     0\romannumeral-‘0#1,,^}%
3477 \def\xINT_xorof:_a #1#2,{\expandafter\xINT_xorof:_b\romannumeral-‘0#2,#1}%
3478 \def\xINT_xorof:_b #1{\if #1,\expandafter\xINT_:_e
3479     \else\expandafter\xINT_xorof:_c\fi #1}%
3480 \def\xINT_xorof:_c #1,#2%
3481     {\xintifTrueAelseB {#1}{\if #20\xint_afterfi{\XINT_xorof:_a 1}%
3482         \else\xint_afterfi{\XINT_xorof:_a 0}\fi}%
3483     {\XINT_xorof:_a #2}%
3484     }%
3485 \def\xINT_:_e ,#1#2^{#1}% allows empty list

```

**36.67 \xintiMaxof:csv**

1.09i. For use by \xintiexpr.

```

3486 \def\xintiMaxof:csv #1{\expandafter\xINT_imaxof:_b\romannumeral-‘0#1,,}%
3487 \def\xINT_imaxof:_b #1,#2,{\expandafter\xINT_imaxof:_c\romannumeral-‘0#2,{#1},}%
3488 \def\xINT_imaxof:_c #1{\if #1,\expandafter\xINT_of:_e
3489     \else\expandafter\xINT_imaxof:_d\fi #1}%
3490 \def\xINT_imaxof:_d #1,{\expandafter\xINT_imaxof:_b\romannumeral0\xintimax {#1}}%
3491 \def\xINT_of:_e ,#1,{#1}%
3492 \let\xintMaxof:csv\xintiMaxof:csv

```

**36.68 \xintiMinof:csv**

1.09i. For use by \xintiexpr.

```

3493 \def\xintiMinof:csv #1{\expandafter\xINT_iminof:_b\romannumeral-‘0#1,,}%
3494 \def\xINT_iminof:_b #1,#2,{\expandafter\xINT_iminof:_c\romannumeral-‘0#2,{#1},}%
3495 \def\xINT_iminof:_c #1{\if #1,\expandafter\xINT_of:_e
3496     \else\expandafter\xINT_iminof:_d\fi #1}%
3497 \def\xINT_iminof:_d #1,{\expandafter\xINT_iminof:_b\romannumeral0\xintimin {#1}}%
3498 \let\xintMinof:csv\xintiMinof:csv

```

**36.69 \xintiiSum:csv**

1.09i. For use by \xintiexpr.

```

3499 \def\xintiiSum:csv #1{\expandafter\XINT_iisum:_a\romannumeral-‘0#1,,^}%
3500 \def\XINT_iisum:_a {\XINT_iisum:_b {0}}%
3501 \def\XINT_iisum:_b #1#2,{\expandafter\XINT_iisum:_c\romannumeral-‘0#2,{#1}}%
3502 \def\XINT_iisum:_c #1{\if #1,\expandafter\XINT_:_e
3503         \else\expandafter\XINT_iisum:_d\fi #1}%
3504 \def\XINT_iisum:_d #1,#2{\expandafter\XINT_iisum:_b\expandafter
3505         {\romannumeral0\xintiiadd {#2}{#1}}}%
3506 \let\xintSum:csv\xintiiSum:csv

```

**36.70 \xintiiPrd:csv**

1.09i. For use by \xintiexpr.

```

3507 \def\xintiiPrd:csv #1{\expandafter\XINT_iiprd:_a\romannumeral-‘0#1,,^}%
3508 \def\XINT_iiprd:_a {\XINT_iiprd:_b {1}}%
3509 \def\XINT_iiprd:_b #1#2,{\expandafter\XINT_iiprd:_c\romannumeral-‘0#2,{#1}}%
3510 \def\XINT_iiprd:_c #1{\if #1,\expandafter\XINT_:_e
3511         \else\expandafter\XINT_iiprd:_d\fi #1}%
3512 \def\XINT_iiprd:_d #1,#2{\expandafter\XINT_iiprd:_b\expandafter
3513         {\romannumeral0\xintiimul {#2}{#1}}}%
3514 \let\xintPrd:csv\xintiiPrd:csv
3515 \XINT_restorecatcodes_endinput%

```

**37 Package **xintbinhex** implementation**

The commenting is currently (2014/01/09) very sparse.

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**37.1 Catcodes,  $\varepsilon$ -T<sub>E</sub>X and reload detection**

The code for reload detection is copied from HEIKO OBERDIEK’s packages, and adapted here to check for previous loading of the master **xint** package.

The method for catcodes is slightly different, but still directly inspired by these packages.

```

1 \begingroup\catcode61\catcode48\catcode32=10\relax%
2  \catcode13=5      % ^^M
3  \endlinechar=13 %
4  \catcode123=1     % {
5  \catcode125=2     % }
6  \catcode64=11     % @
7  \catcode35=6      % #
8  \catcode44=12     % ,
9  \catcode45=12     % -
10 \catcode46=12     % .
11 \catcode58=12     % :
12 \def\space { }%
13 \let\z\endgroup
14 \expandafter\let\expandafter\x\csname ver@xintbinhex.sty\endcsname
15 \expandafter\let\expandafter\w\csname ver@xint.sty\endcsname
16 \expandafter
17   \ifx\csname PackageInfo\endcsname\relax
18     \def\y#1#2{\immediate\write-1{Package #1 Info: #2.}}%
19   \else
20     \def\y#1#2{\PackageInfo{#1}{#2}}%
21   \fi
22 \expandafter
23 \ifx\csname numexpr\endcsname\relax
24   \y{xintbinhex}{numexpr not available, aborting input}%
25   \aftergroup\endinput
26 \else
27   \ifx\x\relax    % plain-TeX, first loading of xintbinhex.sty
28     \ifx\w\relax  % but xint.sty not yet loaded.
29       \y{xintbinhex}{now issuing \string\input\space xint.sty}%
30       \def\z{\endgroup\input xint.sty\relax}%
31     \fi
32   \else
33     \def\empty {}%
34     \ifx\x\empty  % LaTeX, first loading,
35       % variable is initialized, but \ProvidesPackage not yet seen
36       \ifx\w\relax % xint.sty not yet loaded.
37         \y{xintbinhex}{now issuing \string\RequirePackage{xint}}%
38         \def\z{\endgroup\RequirePackage{xint}}%
39       \fi
40     \else
41       \y{xintbinhex}{I was already loaded, aborting input}%
42       \aftergroup\endinput
43     \fi
44   \fi
45 \fi
46 \z%

```

## 37.2 Confirmation of *xint* loading

```

47 \begingroup\catcode61\catcode48\catcode32=10\relax%
48 \catcode13=5 % ^^M
49 \endlinechar=13 %
50 \catcode123=1 % {
51 \catcode125=2 % }
52 \catcode64=11 % @
53 \catcode35=6 % #
54 \catcode44=12 % ,
55 \catcode45=12 % -
56 \catcode46=12 % .
57 \catcode58=12 % :
58 \ifdefined\PackageInfo
59 \def\y#1#2{\PackageInfo{#1}{#2}}%
60 \else
61 \def\y#1#2{\immediate\write-1{Package #1 Info: #2.}}%
62 \fi
63 \def\empty {}%
64 \expandafter\let\expandafter\w\csname ver@xint.sty\endcsname
65 \ifx\w\relax % Plain TeX, user gave a file name at the prompt
66 \y{xintbinhex}{Loading of package xint failed, aborting input}%
67 \aftergroup\endinput
68 \fi
69 \ifx\w\empty % LaTeX, user gave a file name at the prompt
70 \y{xintbinhex}{Loading of package xint failed, aborting input}%
71 \aftergroup\endinput
72 \fi
73 \endgroup%

```

### 37.3 Catcodes

```
74 \XINTsetupcatcodes%
```

### 37.4 Package identification

```

75 \XINT_providespackage
76 \ProvidesPackage{xintbinhex}%
77 [2014/01/09 v1.09j Expandable binary and hexadecimal conversions (jfb)]%

```

### 37.5 Constants, etc...

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```

78 \chardef\xint_c_xvi          16
79% \chardef\xint_c_ii^v        32 % already done in xint.sty
80% \chardef\xint_c_ii^vi       64 % already done in xint.sty
81 \chardef\xint_c_ii^vii       128
82 \mathchardef\xint_c_ii^viii  256
83 \mathchardef\xint_c_ii^xii   4096
84 \newcount\xint_c_ii^xv \xint_c_ii^xv 32768
85 \newcount\xint_c_ii^xvi \xint_c_ii^xvi 65536
86 \newcount\xint_c_x^v \xint_c_x^v 100000

```

### 37 Package *xintbinhex* implementation

```

87 \newcount\xint_c_x^ix \xint_c_x^ix 1000000000
88 \def\xINT_tmpa #1{%
89   \expandafter\edef\csname XINT_sdt#1\endcsname
90   {\ifcase #1 0\or 1\or 2\or 3\or 4\or 5\or 6\or 7\or
91     8\or 9\or A\or B\or C\or D\or E\or F\fi}}%
92 \xintApplyInline\xINT_tmpa
93   {{0}{1}{2}{3}{4}{5}{6}{7}{8}{9}{10}{11}{12}{13}{14}{15}}%
94 \def\xINT_tmpa #1{%
95   \expandafter\edef\csname XINT_sdtb#1\endcsname
96   {\ifcase #1
97     0000\or 0001\or 0010\or 0011\or 0100\or 0101\or 0110\or 0111\or
98     1000\or 1001\or 1010\or 1011\or 1100\or 1101\or 1110\or 1111\fi}}%
99 \xintApplyInline\xINT_tmpa
100   {{0}{1}{2}{3}{4}{5}{6}{7}{8}{9}{10}{11}{12}{13}{14}{15}}%
101 \let\xINT_tmpa\relax
102 \expandafter\def\csname XINT_sbtd_0000\endcsname {0}%
103 \expandafter\def\csname XINT_sbtd_0001\endcsname {1}%
104 \expandafter\def\csname XINT_sbtd_0010\endcsname {2}%
105 \expandafter\def\csname XINT_sbtd_0011\endcsname {3}%
106 \expandafter\def\csname XINT_sbtd_0100\endcsname {4}%
107 \expandafter\def\csname XINT_sbtd_0101\endcsname {5}%
108 \expandafter\def\csname XINT_sbtd_0110\endcsname {6}%
109 \expandafter\def\csname XINT_sbtd_0111\endcsname {7}%
110 \expandafter\def\csname XINT_sbtd_1000\endcsname {8}%
111 \expandafter\def\csname XINT_sbtd_1001\endcsname {9}%
112 \expandafter\def\csname XINT_sbtd_1010\endcsname {10}%
113 \expandafter\def\csname XINT_sbtd_1011\endcsname {11}%
114 \expandafter\def\csname XINT_sbtd_1100\endcsname {12}%
115 \expandafter\def\csname XINT_sbtd_1101\endcsname {13}%
116 \expandafter\def\csname XINT_sbtd_1110\endcsname {14}%
117 \expandafter\def\csname XINT_sbtd_1111\endcsname {15}%
118 \expandafter\let\csname XINT_sbth_0000\endcsname\expandafter\endcsname
119   \csname XINT_sbtd_0000\endcsname
120 \expandafter\let\csname XINT_sbth_0001\endcsname\expandafter\endcsname
121   \csname XINT_sbtd_0001\endcsname
122 \expandafter\let\csname XINT_sbth_0010\endcsname\expandafter\endcsname
123   \csname XINT_sbtd_0010\endcsname
124 \expandafter\let\csname XINT_sbth_0011\endcsname\expandafter\endcsname
125   \csname XINT_sbtd_0011\endcsname
126 \expandafter\let\csname XINT_sbth_0100\endcsname\expandafter\endcsname
127   \csname XINT_sbtd_0100\endcsname
128 \expandafter\let\csname XINT_sbth_0101\endcsname\expandafter\endcsname
129   \csname XINT_sbtd_0101\endcsname
130 \expandafter\let\csname XINT_sbth_0110\endcsname\expandafter\endcsname
131   \csname XINT_sbtd_0110\endcsname
132 \expandafter\let\csname XINT_sbth_0111\endcsname\expandafter\endcsname
133   \csname XINT_sbtd_0111\endcsname
134 \expandafter\let\csname XINT_sbth_1000\endcsname\expandafter\endcsname
135   \csname XINT_sbtd_1000\endcsname

```

```

136 \expandafter\let\csname XINT_sbth_1001\expandafter\endcsname
137       \csname XINT_sbtb_1001\endcsname
138 \expandafter\def\csname XINT_sbth_1010\endcsname {A}%
139 \expandafter\def\csname XINT_sbth_1011\endcsname {B}%
140 \expandafter\def\csname XINT_sbth_1100\endcsname {C}%
141 \expandafter\def\csname XINT_sbth_1101\endcsname {D}%
142 \expandafter\def\csname XINT_sbth_1110\endcsname {E}%
143 \expandafter\def\csname XINT_sbth_1111\endcsname {F}%
144 \expandafter\def\csname XINT_shtb_0\endcsname {0000}%
145 \expandafter\def\csname XINT_shtb_1\endcsname {0001}%
146 \expandafter\def\csname XINT_shtb_2\endcsname {0010}%
147 \expandafter\def\csname XINT_shtb_3\endcsname {0011}%
148 \expandafter\def\csname XINT_shtb_4\endcsname {0100}%
149 \expandafter\def\csname XINT_shtb_5\endcsname {0101}%
150 \expandafter\def\csname XINT_shtb_6\endcsname {0110}%
151 \expandafter\def\csname XINT_shtb_7\endcsname {0111}%
152 \expandafter\def\csname XINT_shtb_8\endcsname {1000}%
153 \expandafter\def\csname XINT_shtb_9\endcsname {1001}%
154 \def\XINT_shtb_A {1010}%
155 \def\XINT_shtb_B {1011}%
156 \def\XINT_shtb_C {1100}%
157 \def\XINT_shtb_D {1101}%
158 \def\XINT_shtb_E {1110}%
159 \def\XINT_shtb_F {1111}%
160 \def\XINT_shtb_G {}%
161 \def\XINT_smallhex #1%
162 {%
163     \expandafter\XINT_smallhex_a\expandafter
164     {\the\numexpr (#1+\xint_c_viii)/\xint_c_xvi-\xint_c_i}{#1}%
165 }%
166 \def\XINT_smallhex_a #1#2%
167 {%
168     \csname XINT_sdth_#1\expandafter\expandafter\expandafter\endcsname
169     \csname XINT_sdtb_\the\numexpr #2-\xint_c_xvi*#1\endcsname
170 }%
171 \def\XINT_smallbin #1%
172 {%
173     \expandafter\XINT_smallbin_a\expandafter
174     {\the\numexpr (#1+\xint_c_viii)/\xint_c_xvi-\xint_c_i}{#1}%
175 }%
176 \def\XINT_smallbin_a #1#2%
177 {%
178     \csname XINT_sdtb_#1\expandafter\expandafter\expandafter\endcsname
179     \csname XINT_sdtb_\the\numexpr #2-\xint_c_xvi*#1\endcsname
180 }%

```

### 37.6 \xintDecToHex, \xintDecToBin

v1.08

### 37 Package *xintbinhex* implementation

```

181 \def\xintDecToHex {\romannumeral0\xintdectohex }%
182 \def\xintdectohex #1%
183     {\expandafter\XINT_dth_checkin\romannumeral-‘0#1\W\W\W\W \T}%
184 \def\XINT_dth_checkin #1%
185 {%
186     \xint_UDsignfork
187     #1\XINT_dth_N
188     -{\XINT_dth_P #1}%
189     \krof
190 }%
191 \def\XINT_dth_N {\expandafter\xint_minus_thenstop\romannumeral0\XINT_dth_P }%
192 \def\XINT_dth_P {\expandafter\XINT_dth_III\romannumeral-‘0\XINT_dtbh_I {0.}}%
193 \def\xintDecToBin {\romannumeral0\xintdectobin }%
194 \def\xintdectobin #1%
195     {\expandafter\XINT_dtb_checkin\romannumeral-‘0#1\W\W\W\W \T }%
196 \def\XINT_dtb_checkin #1%
197 {%
198     \xint_UDsignfork
199     #1\XINT_dtb_N
200     -{\XINT_dtb_P #1}%
201     \krof
202 }%
203 \def\XINT_dtb_N {\expandafter\xint_minus_thenstop\romannumeral0\XINT_dtb_P }%
204 \def\XINT_dtb_P {\expandafter\XINT_dtb_III\romannumeral-‘0\XINT_dtbh_I {0.}}%
205 \def\XINT_dtbh_I #1#2#3#4#5%
206 {%
207     \xint_gob_til_W #5\XINT_dtbh_II_a\W\XINT_dtbh_I_a  {{{#2#3#4#5}#1\Z.%
208 }%
209 \def\XINT_dtbh_II_a\W\XINT_dtbh_I_a #1#2{\XINT_dtbh_II_b #2}%
210 \def\XINT_dtbh_II_b #1#2#3#4%
211 {%
212     \xint_gob_til_W
213     #1\XINT_dtbh_II_c
214     #2\XINT_dtbh_II_cii
215     #3\XINT_dtbh_II_ciii
216     \W\XINT_dtbh_II_ciii #1#2#3#4%
217 }%
218 \def\XINT_dtbh_II_c \W\XINT_dtbh_II_cii
219     \W\XINT_dtbh_II_cii
220     \W\XINT_dtbh_II_ciii \W\W\W\W {}{}%
221 \def\XINT_dtbh_II_cii #1\XINT_dtbh_II_ciii #2\W\W\W
222     {\XINT_dtbh_II_d {}{}{#2}{0}}%
223 \def\XINT_dtbh_II_cii\W\XINT_dtbh_II_ciii #1#2\W\W
224     {\XINT_dtbh_II_d {}{}{#1#2}{00}}%
225 \def\XINT_dtbh_II_ciii #1#2#3\W
226     {\XINT_dtbh_II_d {}{}{#1#2#3}{000}}%
227 \def\XINT_dtbh_I_a #1#2#3.%
228 {%
229     \xint_gob_til_Z #3\XINT_dtbh_I_z\Z

```

### 37 Package *xintbinhex* implementation

```

230 \expandafter\XINT_dtbh_I_b\the\numexpr #2+#30000.{#1}%
231 }%
232 \def\XINT_dtbh_I_b #1.%
233 {%
234 \expandafter\XINT_dtbh_I_c\the\numexpr
235 (#1+\xint_c_ii^xv)/\xint_c_ii^xvi-\xint_c_i.#1.%
236 }%
237 \def\XINT_dtbh_I_c #1.#2.%
238 {%
239 \expandafter\XINT_dtbh_I_d\expandafter
240 {\the\numexpr #2-\xint_c_ii^xvi*#1}{#1}%
241 }%
242 \def\XINT_dtbh_I_d #1#2#3{\XINT_dtbh_I_a {#3#1.}{#2}}%
243 \def\XINT_dtbh_I_z\Z\expandafter\XINT_dtbh_I_b\the\numexpr #1+#2.%
244 {%
245 \ifnum #1=\xint_c_ \expandafter\XINT_dtbh_I_end_zb\fi
246 \XINT_dtbh_I_end_za {#1}%
247 }%
248 \def\XINT_dtbh_I_end_za #1#2{\XINT_dtbh_I {#2#1.}}%
249 \def\XINT_dtbh_I_end_zb\XINT_dtbh_I_end_za #1#2{\XINT_dtbh_I {#2}}%
250 \def\XINT_dtbh_II_d #1#2#3#4.%
251 {%
252 \xint_gob_til_Z #4\XINT_dtbh_II_z\Z
253 \expandafter\XINT_dtbh_II_e\the\numexpr #2+#4#3.{#1}{#3}%
254 }%
255 \def\XINT_dtbh_II_e #1.%
256 {%
257 \expandafter\XINT_dtbh_II_f\the\numexpr
258 (#1+\xint_c_ii^xv)/\xint_c_ii^xvi-\xint_c_i.#1.%
259 }%
260 \def\XINT_dtbh_II_f #1.#2.%
261 {%
262 \expandafter\XINT_dtbh_II_g\expandafter
263 {\the\numexpr #2-\xint_c_ii^xvi*#1}{#1}%
264 }%
265 \def\XINT_dtbh_II_g #1#2#3{\XINT_dtbh_II_d {#3#1.}{#2}}%
266 \def\XINT_dtbh_II_z\Z\expandafter\XINT_dtbh_II_e\the\numexpr #1+#2.%
267 {%
268 \ifnum #1=\xint_c_ \expandafter\XINT_dtbh_II_end_zb\fi
269 \XINT_dtbh_II_end_za {#1}%
270 }%
271 \def\XINT_dtbh_II_end_za #1#2#3{{#2#1.\Z.}}%
272 \def\XINT_dtbh_II_end_zb\XINT_dtbh_II_end_za #1#2#3{{#2\Z.}}%
273 \def\XINT_dth_III #1#2.%
274 {%
275 \xint_gob_til_Z #2\XINT_dth_end\Z
276 \expandafter\XINT_dth_III\expandafter
277 {\romannumeral-'0\XINT_dth_small #2.#1}%
278 }%

```

```

279 \def\XINT_dth_small #1.%
280 {%
281   \expandafter\XINT_smallhex\expandafter
282   {\the\numexpr (#1+\xint_c_ii^vii)/\xint_c_ii^viii-\xint_c_i\expandafter}%
283   \romannumeral-'0\expandafter\XINT_smallhex\expandafter
284   {\the\numexpr
285    #1-((#1+\xint_c_ii^vii)/\xint_c_ii^viii-\xint_c_i)*\xint_c_ii^viii}%
286 }%
287 \def\XINT_dth_end\Z\expandafter\XINT_dth_III\expandafter #1#2\T
288 {%
289   \XINT_dth_end_b #1%
290 }%
291 \def\XINT_dth_end_b #1.{\XINT_dth_end_c }%
292 \def\XINT_dth_end_c #1{\xint_gob_til_zero #1\XINT_dth_end_d 0\space #1}%
293 \def\XINT_dth_end_d 0\space 0#1%
294 {%
295   \xint_gob_til_zero #1\XINT_dth_end_e 0\space #1%
296 }%
297 \def\XINT_dth_end_e 0\space 0#1%
298 {%
299   \xint_gob_til_zero #1\XINT_dth_end_f 0\space #1%
300 }%
301 \def\XINT_dth_end_f 0\space 0{ }%
302 \def\XINT_dtb_III #1#2.%
303 {%
304   \xint_gob_til_Z #2\XINT_dtb_end\Z
305   \expandafter\XINT_dtb_III\expandafter
306   {\romannumeral-'0\XINT_dtb_small #2.#1}%
307 }%
308 \def\XINT_dtb_small #1.%
309 {%
310   \expandafter\XINT_smallbin\expandafter
311   {\the\numexpr (#1+\xint_c_ii^vii)/\xint_c_ii^viii-\xint_c_i\expandafter}%
312   \romannumeral-'0\expandafter\XINT_smallbin\expandafter
313   {\the\numexpr
314    #1-((#1+\xint_c_ii^vii)/\xint_c_ii^viii-\xint_c_i)*\xint_c_ii^viii}%
315 }%
316 \def\XINT_dtb_end\Z\expandafter\XINT_dtb_III\expandafter #1#2\T
317 {%
318   \XINT_dtb_end_b #1%
319 }%
320 \def\XINT_dtb_end_b #1.{\XINT_dtb_end_c }%
321 \def\XINT_dtb_end_c #1#2#3#4#5#6#7#8%
322 {%
323   \expandafter\XINT_dtb_end_d\the\numexpr #1#2#3#4#5#6#7#8\relax
324 }%
325 \edef\XINT_dtb_end_d #1#2#3#4#5#6#7#8#9%
326 {%
327   \noexpand\expandafter\space\noexpand\the\numexpr #1#2#3#4#5#6#7#8#9\relax

```

328 }%

### 37.7 \xintHexToDec

v1.08

```

329 \def\xintHexToDec {\romannumeral0\xinthextodec }%
330 \def\xinthextodec #1%
331     {\expandafter\XINT_htd_checkin\romannumeral-'0#1\W\W\W\W \T }%
332 \def\XINT_htd_checkin #1%
333 {%
334     \xint_UDsignfork
335     #1\XINT_htd_neg
336     -{\XINT_htd_I {0000}#1}%
337     \krof
338 }%
339 \def\XINT_htd_neg {\expandafter\xint_minus_thenstop
340     \romannumeral0\XINT_htd_I {0000}}%
341 \def\XINT_htd_I #1#2#3#4#5%
342 {%
343     \xint_gob_til_W #5\XINT_htd_II_a\W
344     \XINT_htd_I_a {}{"#2#3#4#5}#1\Z\Z\Z\Z
345 }%
346 \def\XINT_htd_II_a \W\XINT_htd_I_a #1#2{\XINT_htd_II_b #2}%
347 \def\XINT_htd_II_b "#1#2#3#4%
348 {%
349     \xint_gob_til_W
350     #1\XINT_htd_II_c
351     #2\XINT_htd_II_ci
352     #3\XINT_htd_II_cii
353     \W\XINT_htd_II_ciii #1#2#3#4%
354 }%
355 \def\XINT_htd_II_c \W\XINT_htd_II_ci
356     \W\XINT_htd_II_cii
357     \W\XINT_htd_II_ciii \W\W\W\W #1\Z\Z\Z\Z\T
358 {%
359     \expandafter\xint_cleanupzeros_andstop
360     \romannumeral0\XINT_rord_main {}#1%
361     \xint_relax
362     \xint_bye\xint_bye\xint_bye\xint_bye
363     \xint_bye\xint_bye\xint_bye\xint_bye
364     \xint_relax
365 }%
366 \def\XINT_htd_II_ci #1\XINT_htd_II_ciii
367     #2\W\W\W {\XINT_htd_II_d {}{"#2}{\xint_c_xvi}}%
368 \def\XINT_htd_II_cii\W\XINT_htd_II_ciii
369     #1#2\W\W {\XINT_htd_II_d {}{"#1#2}{\xint_c_ii^viii}}%
370 \def\XINT_htd_II_ciii #1#2#3\W {\XINT_htd_II_d {}{"#1#2#3}{\xint_c_ii^xii}}%
371 \def\XINT_htd_I_a #1#2#3#4#5#6%

```

### 37 Package *xintbinhex* implementation

```
372 {%
373   \xint_gob_til_Z #3\XINT_htd_I_end_a\Z
374   \expandafter\XINT_htd_I_b\the\numexpr
375   #2+\xint_c_ii^xvi*#6#5#4#3+\xint_c_x^ix\relax {#1}%
376 }%
377 \def\XINT_htd_I_b #1#2#3#4#5#6#7#8#9{\XINT_htd_I_c {#1#2#3#4#5}{#9#8#7#6}}%
378 \def\XINT_htd_I_c #1#2#3{\XINT_htd_I_a {#3#2}{#1}}%
379 \def\XINT_htd_I_end_a\Z\expandafter\XINT_htd_I_b\the\numexpr #1+#2\relax
380 {%
381   \expandafter\XINT_htd_I_end_b\the\numexpr \xint_c_x^v+#1\relax
382 }%
383 \def\XINT_htd_I_end_b #1#2#3#4#5%
384 {%
385   \xint_gob_til_zero #1\XINT_htd_I_end_bz0%
386   \XINT_htd_I_end_c #1#2#3#4#5%
387 }%
388 \def\XINT_htd_I_end_c #1#2#3#4#5#6{\XINT_htd_I {#6#5#4#3#2#1000}}%
389 \def\XINT_htd_I_end_bz0\XINT_htd_I_end_c 0#1#2#3#4%
390 {%
391   \xint_gob_til_zeros_iv #1#2#3#4\XINT_htd_I_end_bzz 0000%
392   \XINT_htd_I_end_D {#4#3#2#1}%
393 }%
394 \def\XINT_htd_I_end_D #1#2{\XINT_htd_I {#2#1}}%
395 \def\XINT_htd_I_end_bzz 0000\XINT_htd_I_end_D #1{\XINT_htd_I }%
396 \def\XINT_htd_II_d #1#2#3#4#5#6#7%
397 {%
398   \xint_gob_til_Z #4\XINT_htd_II_end_a\Z
399   \expandafter\XINT_htd_II_e\the\numexpr
400   #2+#3*#7#6#5#4+\xint_c_x^viii\relax {#1}{#3}%
401 }%
402 \def\XINT_htd_II_e #1#2#3#4#5#6#7#8{\XINT_htd_II_f {#1#2#3#4}{#5#6#7#8}}%
403 \def\XINT_htd_II_f #1#2#3{\XINT_htd_II_d {#2#3}{#1}}%
404 \def\XINT_htd_II_end_a\Z\expandafter\XINT_htd_II_e
405   \the\numexpr #1+#2\relax #3#4\T
406 {%
407   \XINT_htd_II_end_b #1#3%
408 }%
409 \edef\XINT_htd_II_end_b #1#2#3#4#5#6#7#8%
410 {%
411   \noexpand\expandafter\space\noexpand\the\numexpr #1#2#3#4#5#6#7#8\relax
412 }%
```

### 37.8 \xintBinToDec

v1.08

```
413 \def\xintBinToDec {\romannumeral0\xintbintodec }%
414 \def\xintbintodec #1{\expandafter\XINT_btd_checkin
415   \romannumeral-'0#1\W\W\W\W\W\W\W\W\T }%
```

```

416 \def\XINT_btd_checkin #1%
417 {%
418   \xint_UDsignfork
419   #1\XINT_btd_neg
420   -{\XINT_btd_I {000000}\#1}%
421   \krof
422 }%
423 \def\XINT_btd_neg {\expandafter\xint_minus_thenstop
424                   \romannumeral0\XINT_btd_I {000000}}%
425 \def\XINT_btd_I #1#2#3#4#5#6#7#8#9%
426 {%
427   \xint_gob_til_W #9\XINT_btd_II_a {#2#3#4#5#6#7#8#9}\W
428   \XINT_btd_I_a {}{\csname XINT_sbtd_#2#3#4#5\endcsname*\xint_c_xvi+%
429               \csname XINT_sbtd_#6#7#8#9\endcsname}%
430   #1\Z\Z\Z\Z\Z\Z
431 }%
432 \def\XINT_btd_II_a #1\W\XINT_btd_I_a #2#3{\XINT_btd_II_b #1}%
433 \def\XINT_btd_II_b #1#2#3#4#5#6#7#8%
434 {%
435   \xint_gob_til_W
436   #1\XINT_btd_II_c
437   #2\XINT_btd_II_ci
438   #3\XINT_btd_II_cii
439   #4\XINT_btd_II_ciii
440   #5\XINT_btd_II_civ
441   #6\XINT_btd_II_cv
442   #7\XINT_btd_II_cvi
443   \W\XINT_btd_II_cvii #1#2#3#4#5#6#7#8%
444 }%
445 \def\XINT_btd_II_c #1\XINT_btd_II_cvii \W\W\W\W\W\W\W\W #2\Z\Z\Z\Z\Z\Z\T
446 {%
447   \expandafter\XINT_btd_II_c_end
448   \romannumeral0\XINT_rord_main {}#2%
449   \xint_relax
450   \xint_bye\xint_bye\xint_bye\xint_bye
451   \xint_bye\xint_bye\xint_bye\xint_bye
452   \xint_relax
453 }%
454 \edef\XINT_btd_II_c_end #1#2#3#4#5#6%
455 {%
456   \noexpand\expandafter\space\noexpand\the\numexpr #1#2#3#4#5#6\relax
457 }%
458 \def\XINT_btd_II_ci #1\XINT_btd_II_cvii #2\W\W\W\W\W\W\W
459   {\XINT_btd_II_d {}{#2}{\xint_c_ii }}%
460 \def\XINT_btd_II_cii #1\XINT_btd_II_cvii #2\W\W\W\W\W\W
461   {\XINT_btd_II_d {}{\csname XINT_sbtd_00#2\endcsname }{\xint_c_iv }}%
462 \def\XINT_btd_II_ciii #1\XINT_btd_II_cvii #2\W\W\W\W\W
463   {\XINT_btd_II_d {}{\csname XINT_sbtd_0#2\endcsname }{\xint_c_viii }}%
464 \def\XINT_btd_II_civ #1\XINT_btd_II_cvii #2\W\W\W\W

```

### 37 Package *xintbinhex* implementation

```

465   {\XINT_btd_II_d {}{\csname XINT_sbtd_#2\endcsname}{\xint_c_xvi }}%
466 \def\XINT_btd_II_cv #1\XINT_btd_II_cvii #2#3#4#5#6\W\W\W
467 {%
468   \XINT_btd_II_d {}{\csname XINT_sbtd_#2#3#4#5\endcsname*\xint_c_ii+%
469     #6}{\xint_c_ii^v }}%
470 }%
471 \def\XINT_btd_II_cvi #1\XINT_btd_II_cvii #2#3#4#5#6#7\W\W
472 {%
473   \XINT_btd_II_d {}{\csname XINT_sbtd_#2#3#4#5\endcsname*\xint_c_iv+%
474     \csname XINT_sbtd_00#6#7\endcsname}{\xint_c_ii^vi }}%
475 }%
476 \def\XINT_btd_II_cvii #1#2#3#4#5#6#7\W
477 {%
478   \XINT_btd_II_d {}{\csname XINT_sbtd_#1#2#3#4\endcsname*\xint_c_viii+%
479     \csname XINT_sbtd_0#5#6#7\endcsname}{\xint_c_ii^vii }}%
480 }%
481 \def\XINT_btd_II_d #1#2#3#4#5#6#7#8#9%
482 {%
483   \xint_gob_til_Z #4\XINT_btd_II_end_a\Z
484   \expandafter\XINT_btd_II_e\the\numexpr
485     #2+(\xint_c_x^ix+#3*#9#8#7#6#5#4)\relax {#1}{#3}%
486 }%
487 \def\XINT_btd_II_e #1#2#3#4#5#6#7#8#9{\XINT_btd_II_f {#1#2#3}{#4#5#6#7#8#9}}%
488 \def\XINT_btd_II_f #1#2#3{\XINT_btd_II_d {#2#3}{#1}}%
489 \def\XINT_btd_II_end_a\Z\expandafter\XINT_btd_II_e
490   \the\numexpr #1+(\Z\relax #3#4\T
491 {%
492   \XINT_btd_II_end_b #1#3%
493 }%
494 \edef\XINT_btd_II_end_b #1#2#3#4#5#6#7#8#9%
495 {%
496   \noexpand\expandafter\space\noexpand\the\numexpr #1#2#3#4#5#6#7#8#9\relax
497 }%
498 \def\XINT_btd_I_a #1#2#3#4#5#6#7#8%
499 {%
500   \xint_gob_til_Z #3\XINT_btd_I_end_a\Z
501   \expandafter\XINT_btd_I_b\the\numexpr
502     #2+\xint_c_ii^viii*#8#7#6#5#4#3+\xint_c_x^ix\relax {#1}%
503 }%
504 \def\XINT_btd_I_b #1#2#3#4#5#6#7#8#9{\XINT_btd_I_c {#1#2#3}{#9#8#7#6#5#4}}%
505 \def\XINT_btd_I_c #1#2#3{\XINT_btd_I_a {#3#2}{#1}}%
506 \def\XINT_btd_I_end_a\Z\expandafter\XINT_btd_I_b
507   \the\numexpr #1+\xint_c_ii^viii #2\relax
508 {%
509   \expandafter\XINT_btd_I_end_b\the\numexpr 1000+#1\relax
510 }%
511 \def\XINT_btd_I_end_b #1#2#3%
512 {%
513   \xint_gob_til_zeros_iii #1#2#3\XINT_btd_I_end_bz 000%

```

### 37 Package *xintbinhex* implementation

```
514 \XINT_btd_I_end_c #1#2#3%
515 }%
516 \def\XINT_btd_I_end_c #1#2#3#4{\XINT_btd_I {#4#3#2#1000}}%
517 \def\XINT_btd_I_end_bz 000\XINT_btd_I_end_c 000{\XINT_btd_I }%
```

#### 37.9 \xintBinToHex

v1.08

```
518 \def\xintBinToHex {\romannumeral0\xintbinto hex }%
519 \def\xintbinto hex #1%
520 {%
521 \expandafter\XINT_bth_checkin
522 \romannumeral0\expandafter\XINT_num_loop
523 \romannumeral-‘0#1\xint_relax\xint_relax
524 \xint_relax\xint_relax
525 \xint_relax\xint_relax\xint_relax\xint_relax\Z
526 \R\R\R\R\R\R\R\R\Z \W\W\W\W\W\W\W\W
527 }%
528 \def\XINT_bth_checkin #1%
529 {%
530 \xint_UDsignfork
531 #1\XINT_bth_N
532 -{\XINT_bth_P #1}%
533 \krof
534 }%
535 \def\XINT_bth_N {\expandafter\xint_minus_thenstop\romannumeral0\XINT_bth_P }%
536 \def\XINT_bth_P {\expandafter\XINT_bth_I\expandafter{\expandafter}%
537 \romannumeral0\XINT_OQ {}}%
538 \def\XINT_bth_I #1#2#3#4#5#6#7#8#9%
539 {%
540 \xint_gob_til_W #9\XINT_bth_end_a\W
541 \expandafter\expandafter\expandafter
542 \XINT_bth_I
543 \expandafter\expandafter\expandafter
544 {\csname XINT_sbth_#9#8#7#6\expandafter\expandafter\expandafter\endcsname
545 \csname XINT_sbth_#5#4#3#2\endcsname #1}%
546 }%
547 \def\XINT_bth_end_a\W \expandafter\expandafter\expandafter
548 \XINT_bth_I \expandafter\expandafter\expandafter #1%
549 {%
550 \XINT_bth_end_b #1%
551 }%
552 \def\XINT_bth_end_b #1\endcsname #2\endcsname #3%
553 {%
554 \xint_gob_til_zero #3\XINT_bth_end_z 0\space #3%
555 }%
556 \def\XINT_bth_end_z0\space 0{ }%
```

**37.10 \xintHexToBin**

v1.08

```

557 \def\xintHexToBin {\romannumeral0\xinthextobin }%
558 \def\xinthextobin #1%
559 {%
560   \expandafter\XINT_htb_checkin\romannumeral-'0#1GGGGGGGG\T
561 }%
562 \def\XINT_htb_checkin #1%
563 {%
564   \xint_UDsignfork
565     #1\XINT_htb_N
566     -{\XINT_htb_P #1}%
567   \krof
568 }%
569 \def\XINT_htb_N {\expandafter\xint_minus_thenstop\romannumeral0\XINT_htb_P }%
570 \def\XINT_htb_P {\XINT_htb_I_a {}}%
571 \def\XINT_htb_I_a #1#2#3#4#5#6#7#8#9%
572 {%
573   \xint_gob_til_G #9\XINT_htb_II_a G%
574   \expandafter\expandafter\expandafter
575   \XINT_htb_I_b
576   \expandafter\expandafter\expandafter
577   {\csname XINT_shbt_#2\expandafter\expandafter\expandafter\endcsname
578    \csname XINT_shbt_#3\expandafter\expandafter\expandafter\endcsname
579    \csname XINT_shbt_#4\expandafter\expandafter\expandafter\endcsname
580    \csname XINT_shbt_#5\expandafter\expandafter\expandafter\endcsname
581    \csname XINT_shbt_#6\expandafter\expandafter\expandafter\endcsname
582    \csname XINT_shbt_#7\expandafter\expandafter\expandafter\endcsname
583    \csname XINT_shbt_#8\expandafter\expandafter\expandafter\endcsname
584    \csname XINT_shbt_#9\endcsname }{#1}%
585 }%
586 \def\XINT_htb_I_b #1#2{\XINT_htb_I_a {#2#1}}%
587 \def\XINT_htb_II_a G\expandafter\expandafter\expandafter\XINT_htb_I_b
588 {%
589   \expandafter\expandafter\expandafter \XINT_htb_II_b
590 }%
591 \def\XINT_htb_II_b #1#2#3\T
592 {%
593   \XINT_num_loop #2#1%
594   \xint_relax\xint_relax\xint_relax\xint_relax
595   \xint_relax\xint_relax\xint_relax\xint_relax\Z
596 }%

```

**37.11 \xintCHexToBin**

v1.08

```

597 \def\xintCHexToBin {\romannumeral0\xintchextobin }%
598 \def\xintchextobin #1%
599 {%
600   \expandafter\XINT_chtb_checkin\romannumeral-‘0#1%
601   \R\R\R\R\R\R\R\R\Z \W\W\W\W\W\W\W\W
602 }%
603 \def\XINT_chtb_checkin #1%
604 {%
605   \xint_UDsignfork
606   #1\XINT_chtb_N
607   -{\XINT_chtb_P #1}%
608   \krof
609 }%
610 \def\XINT_chtb_N {\expandafter\xint_minus_thenstop\romannumeral0\XINT_chtb_P }%
611 \def\XINT_chtb_P {\expandafter\XINT_chtb_I\expandafter{\expandafter}%
612   \romannumeral0\XINT_OQ {}}%
613 \def\XINT_chtb_I #1#2#3#4#5#6#7#8#9%
614 {%
615   \xint_gob_til_W #9\XINT_chtb_end_a\W
616   \expandafter\expandafter\expandafter
617   \XINT_chtb_I
618   \expandafter\expandafter\expandafter
619   {\csname XINT_shtb_#9\expandafter\expandafter\expandafter\endcsname
620   \csname XINT_shtb_#8\expandafter\expandafter\expandafter\endcsname
621   \csname XINT_shtb_#7\expandafter\expandafter\expandafter\endcsname
622   \csname XINT_shtb_#6\expandafter\expandafter\expandafter\endcsname
623   \csname XINT_shtb_#5\expandafter\expandafter\expandafter\endcsname
624   \csname XINT_shtb_#4\expandafter\expandafter\expandafter\endcsname
625   \csname XINT_shtb_#3\expandafter\expandafter\expandafter\endcsname
626   \csname XINT_shtb_#2\endcsname
627   #1}%
628 }%
629 \def\XINT_chtb_end_a\W\expandafter\expandafter\expandafter
630   \XINT_chtb_I\expandafter\expandafter\expandafter #1%
631 {%
632   \XINT_chtb_end_b #1%
633   \xint_relax\xint_relax\xint_relax\xint_relax
634   \xint_relax\xint_relax\xint_relax\xint_relax\Z
635 }%
636 \def\XINT_chtb_end_b #1\W#2\W#3\W#4\W#5\W#6\W#7\W#8\W\endcsname
637 {%
638   \XINT_num_loop
639 }%
640 \XINT_restorecatcodes_endinput%

```

## 38 Package *xintgcd* implementation

The commenting is currently (2014/01/09) very sparse. Release 1.09h has modified a bit the `\xintTypesetEuclideanAlgorithm` and `\xintTypesetBezoutAlgorithm` layout with respect to line indentation in particular. And they use the *xinttools* `\xintloop` rather than the Plain  $\text{T}_{\text{E}}\text{X}$  or  $\text{L}^{\text{A}}\text{T}_{\text{E}}\text{X}$ 's `\loop`.

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### 38.1 Catcodes, $\varepsilon$ - $\text{T}_{\text{E}}\text{X}$ and reload detection

The code for reload detection is copied from HEIKO OBERDIEK's packages, and adapted here to check for previous loading of the master **xint** package.

The method for catcodes is slightly different, but still directly inspired by these packages.

```

1 \begingroup\catcode61\catcode48\catcode32=10\relax%
2 \catcode13=5 % ^^M
3 \endlinechar=13 %
4 \catcode123=1 % {
5 \catcode125=2 % }
6 \catcode64=11 % @
7 \catcode35=6 % #
8 \catcode44=12 % ,
9 \catcode45=12 % -
10 \catcode46=12 % .
11 \catcode58=12 % :
12 \def\space { }%
13 \let\z\endgroup
14 \expandafter\let\expandafter\x\csname ver@xintgcd.sty\endcsname
15 \expandafter\let\expandafter\w\csname ver@xint.sty\endcsname
16 \expandafter
17 \ifx\csname PackageInfo\endcsname\relax
18 \def\y#1#2{\immediate\write-1{Package #1 Info: #2.}}%
19 \else
20 \def\y#1#2{\PackageInfo{#1}{#2}}%
21 \fi
22 \expandafter
23 \ifx\csname numexpr\endcsname\relax

```

```

24 \y{xintgcd}{\numexpr not available, aborting input}%
25 \aftergroup\endinput
26 \else
27 \ifx\x\relax % plain-TeX, first loading of xintgcd.sty
28 \ifx\w\relax % but xint.sty not yet loaded.
29 \y{xintgcd}{now issuing \string\input\space xint.sty}%
30 \def\z{\endgroup\input xint.sty\relax}%
31 \fi
32 \else
33 \def\empty {}%
34 \ifx\x\empty % LaTeX, first loading,
35 % variable is initialized, but \ProvidesPackage not yet seen
36 \ifx\w\relax % xint.sty not yet loaded.
37 \y{xintgcd}{now issuing \string\RequirePackage{xint}}%
38 \def\z{\endgroup\RequirePackage{xint}}%
39 \fi
40 \else
41 \y{xintgcd}{I was already loaded, aborting input}%
42 \aftergroup\endinput
43 \fi
44 \fi
45 \fi
46 \z%

```

### 38.2 Confirmation of *xint* loading

```

47 \begingroup\catcode61\catcode48\catcode32=10\relax%
48 \catcode13=5 % ^^M
49 \endlinechar=13 %
50 \catcode123=1 % {
51 \catcode125=2 % }
52 \catcode64=11 % @
53 \catcode35=6 % #
54 \catcode44=12 % ,
55 \catcode45=12 % -
56 \catcode46=12 % .
57 \catcode58=12 % :
58 \ifdefined\PackageInfo
59 \def\y#1#2{\PackageInfo{#1}{#2}}%
60 \else
61 \def\y#1#2{\immediate\write-1{Package #1 Info: #2.}}%
62 \fi
63 \def\empty {}%
64 \expandafter\let\expandafter\w\csname ver@xint.sty\endcsname
65 \ifx\w\relax % Plain TeX, user gave a file name at the prompt
66 \y{xintgcd}{Loading of package xint failed, aborting input}%
67 \aftergroup\endinput
68 \fi
69 \ifx\w\empty % LaTeX, user gave a file name at the prompt

```

```

70      \y{xintgcd}{Loading of package xint failed, aborting input}%
71      \aftergroup\endinput
72  \fi
73 \endgroup%

```

### 38.3 Catcodes

```

74 \XINTsetupcatcodes%

```

### 38.4 Package identification

```

75 \XINT_providespackage
76 \ProvidesPackage{xintgcd}%
77 [2014/01/09 v1.09j Euclidean algorithm with xint package (jfb)]%

```

### 38.5 \xintGCD

The macros of 1.09a benefits from the `\xintnum` which has been inserted inside `\xintiabs` in **xint**; this is a little overhead but is more convenient for the user and also makes it easier to use into `\xint-` expressions.

```

78 \def\xintGCD {\romannumeral0\xintgcd }%
79 \def\xintgcd #1%
80 {%
81   \expandafter\XINT_gcd\expandafter{\romannumeral0\xintiabs {#1}}%
82 }%
83 \def\XINT_gcd #1#2%
84 {%
85   \expandafter\XINT_gcd_fork\romannumeral0\xintiabs {#2}\Z #1\Z
86 }%
87 \def\XINT_gcd_fork #1#2\Z #3#4\Z
88 {%
89   \xint_UDzerofork
90     #1\XINT_gcd_BisZero
91     #3\XINT_gcd_AisZero
92     0\XINT_gcd_loop
93   \krof
94   {#1#2}{#3#4}%
95 }%
96 \def\XINT_gcd_AisZero #1#2{ #1}%
97 \def\XINT_gcd_BisZero #1#2{ #2}%
98 \def\XINT_gcd_CheckRem #1#2\Z
99 {%
100   \xint_gob_til_zero #1\xintgcd_end0\XINT_gcd_loop {#1#2}%
101 }%
102 \def\xintgcd_end0\XINT_gcd_loop #1#2{ #2}%

```

#1=B, #2=A

```

103 \def\XINT_gcd_loop #1#2%

```

```

104 {%
105   \expandafter\expandafter\expandafter
106   \XINT_gcd_CheckRem
107   \expandafter\xint_seconsoftwo
108   \romannumeral0\XINT_div_prepare {#1}{#2}\Z
109   {#1}%
110 }%

```

### 38.6 \xintGCDof

New with 1.09a. I also tried an optimization (not working two by two) which I thought was clever but it seemed to be less efficient ...

```

111 \def\xintGCDof      {\romannumeral0\xintgcdof }%
112 \def\xintgcdof      #1{\expandafter\XINT_gcdof_a\romannumeral-‘0#1\relax }%
113 \def\XINT_gcdof_a   #1{\expandafter\XINT_gcdof_b\romannumeral-‘0#1\Z }%
114 \def\XINT_gcdof_b   #1\Z #2{\expandafter\XINT_gcdof_c\romannumeral-‘0#2\Z {#1}\Z}%
115 \def\XINT_gcdof_c   #1{\xint_gob_til_relax #1\XINT_gcdof_e\relax\XINT_gcdof_d #1}%
116 \def\XINT_gcdof_d   #1\Z {\expandafter\XINT_gcdof_b\romannumeral0\xintgcd {#1}}%
117 \def\XINT_gcdof_e   #1\Z #2\Z { #2}%

```

### 38.7 \xintLCM

New with 1.09a. Inadvertent use of \xintiQuo which was promoted at the same time to add the \xintnum overhead. So with 1.09f \xintiiQuo without the overhead.

```

118 \def\xintLCM {\romannumeral0\xintlcm}%
119 \def\xintlcm #1%
120 {%
121   \expandafter\XINT_lcm\expandafter{\romannumeral0\xintiabs {#1}}%
122 }%
123 \def\XINT_lcm #1#2%
124 {%
125   \expandafter\XINT_lcm_fork\romannumeral0\xintiabs {#2}\Z #1\Z
126 }%
127 \def\XINT_lcm_fork #1#2\Z #3#4\Z
128 {%
129   \xint_UDzerofork
130   #1\XINT_lcm_BisZero
131   #3\XINT_lcm_AisZero
132   0\expandafter
133   \krof
134   \XINT_lcm_notzero\expandafter{\romannumeral0\XINT_gcd_loop {#1#2}{#3#4}}%
135   {#1#2}{#3#4}%
136 }%
137 \def\XINT_lcm_AisZero #1#2#3#4#5{ 0}%
138 \def\XINT_lcm_BisZero #1#2#3#4#5{ 0}%
139 \def\XINT_lcm_notzero #1#2#3{\xintiimul {#2}{\xintiiQuo{#3}{#1}}}%

```

**38.8 \xintLCMof**

New with 1.09a

```

140 \def\xintLCMof      {\romannumeral0\xintlcmof }%
141 \def\xintlcmof      #1{\expandafter\xINT_lcmof_a\romannumeral-‘0#1\relax }%
142 \def\xINT_lcmof_a   #1{\expandafter\xINT_lcmof_b\romannumeral-‘0#1\Z }%
143 \def\xINT_lcmof_b   #1\Z #2{\expandafter\xINT_lcmof_c\romannumeral-‘0#2\Z {#1}\Z}%
144 \def\xINT_lcmof_c   #1{\xint_gob_til_relax #1\xINT_lcmof_e\relax\xINT_lcmof_d #1}%
145 \def\xINT_lcmof_d   #1\Z {\expandafter\xINT_lcmof_b\romannumeral0\xintlcm {#1}}%
146 \def\xINT_lcmof_e   #1\Z #2\Z { #2}%

```

**38.9 \xintBezout**

1.09a inserts use of \xintnum

```

147 \def\xintBezout {\romannumeral0\xintbezout }%
148 \def\xintbezout #1%
149 {%
150   \expandafter\xint_bezout\expandafter {\romannumeral0\xintnum{#1}}%
151 }%
152 \def\xint_bezout #1#2%
153 {%
154   \expandafter\xINT_bezout_fork \romannumeral0\xintnum{#2}\Z #1\Z
155 }%

#3#4 = A, #1#2=B

156 \def\xINT_bezout_fork #1#2\Z #3#4\Z
157 {%
158   \xint_UDzerosfork
159   #1#3\xINT_bezout_botharezero
160   #10\xINT_bezout_secondiszero
161   #30\xINT_bezout_firstiszero
162   00{\xint_UDsignsfork
163     #1#3\xINT_bezout_minusminus % A < 0, B < 0
164     #1-\xINT_bezout_minusplus  % A > 0, B < 0
165     #3-\xINT_bezout_plusminus  % A < 0, B > 0
166     --\xINT_bezout_plusplus   % A > 0, B > 0
167   \krof }%
168   \krof
169   {#2}{#4}#1#3{#3#4}{#1#2}% #1#2=B, #3#4=A
170 }%
171 \edef\xINT_bezout_botharezero #1#2#3#4#5#6%
172 {%
173   \noexpand\xintError:NoBezoutForZeros
174   \space {0}{0}{0}{0}{0}%
175 }%

```

### 38 Package *xintgcd* implementation

attention première entrée doit être ici  $(-1)^n$  donc 1  
 $\#4\#2 = 0 = A, B = \#3\#1$

```
176 \def\XINT_bezout_firstiszero #1#2#3#4#5#6%
177 {%
178   \xint_UDsignfork
179     #3{ {0}{#3#1}{0}{1}{#1}}%
180     -{ {0}{#3#1}{0}{-1}{#1}}%
181   \krof
182 }%
```

$\#4\#2 = A, B = \#3\#1 = 0$

```
183 \def\XINT_bezout_secondiszero #1#2#3#4#5#6%
184 {%
185   \xint_UDsignfork
186     #4{ {#4#2}{0}{-1}{0}{#2}}%
187     -{ {#4#2}{0}{1}{0}{#2}}%
188   \krof
189 }%
```

$\#4\#2 = A < 0, \#3\#1 = B < 0$

```
190 \def\XINT_bezout_minusminus #1#2#3#4%
191 {%
192   \expandafter\XINT_bezout_mm_post
193   \romannumeral0\XINT_bezout_loop_a 1{#1}{#2}1001%
194 }%
195 \def\XINT_bezout_mm_post #1#2%
196 {%
197   \expandafter\XINT_bezout_mm_postb\expandafter
198   {\romannumeral0\xintiopp{#2}}{\romannumeral0\xintiopp{#1}}%
199 }%
200 \def\XINT_bezout_mm_postb #1#2%
201 {%
202   \expandafter\XINT_bezout_mm_postc\expandafter {#2}{#1}%
203 }%
204 \edef\XINT_bezout_mm_postc #1#2#3#4#5%
205 {%
206   \space {#4}{#5}{#1}{#2}{#3}%
207 }%
```

minusplus  $\#4\#2 = A > 0, B < 0$

```
208 \def\XINT_bezout_minusplus #1#2#3#4%
209 {%
210   \expandafter\XINT_bezout_mp_post
211   \romannumeral0\XINT_bezout_loop_a 1{#1}{#4#2}1001%
212 }%
213 \def\XINT_bezout_mp_post #1#2%
```

```

214 {%
215   \expandafter\XINT_bezout_mp_postb\expandafter
216   {\romannumeral0\xintiiopp {#2}}{#1}%
217 }%
218 \edef\XINT_bezout_mp_postb #1#2#3#4#5%
219 {%
220   \space {#4}{#5}{#2}{#1}{#3}%
221 }%

plusminus A < 0, B > 0

222 \def\XINT_bezout_plusminus #1#2#3#4%
223 {%
224   \expandafter\XINT_bezout_pm_post
225   \romannumeral0\XINT_bezout_loop_a 1{#3#1}{#2}1001%
226 }%
227 \def\XINT_bezout_pm_post #1%
228 {%
229   \expandafter \XINT_bezout_pm_postb \expandafter
230   {\romannumeral0\xintiiopp{#1}}%
231 }%
232 \edef\XINT_bezout_pm_postb #1#2#3#4#5%
233 {%
234   \space {#4}{#5}{#1}{#2}{#3}%
235 }%

plusplus

236 \def\XINT_bezout_plusplus #1#2#3#4%
237 {%
238   \expandafter\XINT_bezout_pp_post
239   \romannumeral0\XINT_bezout_loop_a 1{#3#1}{#4#2}1001%
240 }%

la parité  $(-1)^N$  est en #1, et on la jette ici.

241 \edef\XINT_bezout_pp_post #1#2#3#4#5%
242 {%
243   \space {#4}{#5}{#1}{#2}{#3}%
244 }%

n = 0: 1BAalpha(0)beta(0)alpha(-1)beta(-1)
n général:  $\{(-1)^n\{r(n-1)\}\{r(n-2)\}\{\alpha(n-1)\}\{\beta(n-1)\}\{\alpha(n-2)\}\{\beta(n-2)\}\}$ 
#2 = B, #3 = A

245 \def\XINT_bezout_loop_a #1#2#3%
246 {%
247   \expandafter\XINT_bezout_loop_b
248   \expandafter{\the\numexpr -#1\expandafter}%
249   \romannumeral0\XINT_div_prepare {#2}{#3}{#2}%
250 }%
```

Le  $q(n)$  a ici une existence éphémère, dans le version Bezout Algorithm il faudra le conserver. On voudra à la fin  $\{q(n)\{r(n)\{\alpha(n)\{\beta(n)\}\}$ . De plus ce n'est plus  $(-1)^n$  que l'on veut mais  $n$ . (ou dans un autre ordre)

$\{-(-1)^n\{q(n)\{r(n)\{r(n-1)\{\alpha(n-1)\{\beta(n-1)\{\alpha(n-2)\{\beta(n-2)\}$

```

251 \def\XINT_bezout_loop_b #1#2#3#4#5#6#7#8%
252 {%
253   \expandafter \XINT_bezout_loop_c \expandafter
254     {\romannumeral0\xintiiadd{\XINT_Mul{#5}{#2}}{#7}}%
255     {\romannumeral0\xintiiadd{\XINT_Mul{#6}{#2}}{#8}}%
256     {#1}{#3}{#4}{#5}{#6}%
257 }%

{\alpha(n)\{->\beta(n)\}\{-(-1)^n\{r(n)\{r(n-1)\{\alpha(n-1)\{\beta(n-1)\}

258 \def\XINT_bezout_loop_c #1#2%
259 {%
260   \expandafter \XINT_bezout_loop_d \expandafter
261     {#2}{#1}%
262 }%

{\beta(n)\{\alpha(n)\}\{(-1)^{(n+1)}\{r(n)\{r(n-1)\{\alpha(n-1)\{\beta(n-1)\}

263 \def\XINT_bezout_loop_d #1#2#3#4#5%
264 {%
265   \XINT_bezout_loop_e #4\Z {#3}{#5}{#2}{#1}%
266 }%

r(n)\Z {(-1)^{(n+1)}\{r(n-1)\{\alpha(n)\{\beta(n)\{\alpha(n-1)\{\beta(n-1)\}

267 \def\XINT_bezout_loop_e #1#2\Z
268 {%
269   \xint_gob_til_zero #1\xint_bezout_loop_exit0\XINT_bezout_loop_f
270   {#1#2}%
271 }%

{r(n)\{(-1)^{(n+1)}\{r(n-1)\{\alpha(n)\{\beta(n)\{\alpha(n-1)\{\beta(n-1)\}

272 \def\XINT_bezout_loop_f #1#2%
273 {%
274   \XINT_bezout_loop_a {#2}{#1}%
275 }%

{(-1)^{(n+1)}\{r(n)\{r(n-1)\{\alpha(n)\{\beta(n)\{\alpha(n-1)\{\beta(n-1)\} et itéra-
tion

276 \def\xint_bezout_loop_exit0\XINT_bezout_loop_f #1#2%
277 {%
278   \ifcase #2
279   \or \expandafter\XINT_bezout_exiteven
280   \else\expandafter\XINT_bezout_exitodd

```

```

281 \fi
282 }%
283 \edef\XINT_bezout_exiteven #1#2#3#4#5%
284 {%
285 \space {#5}{#4}{#1}%
286 }%
287 \edef\XINT_bezout_exitodd #1#2#3#4#5%
288 {%
289 \space {-#5}{-#4}{#1}%
290 }%

```

### 38.10 \xintEuclideanAlgorithm

Pour Euclide:  $\{N\}\{A\}\{D=r(n)\}\{B\}\{q_1\}\{r_1\}\{q_2\}\{r_2\}\{q_3\}\{r_3\}\dots\{q_N\}\{r_N=0\}$   
 $u_{<2n} = u_{<2n+3} > u_{<2n+2} > + u_{<2n+4} >$  à la  $n$  ième étape

```

291 \def\xintEuclideanAlgorithm {\romannumeral0\xinteuclideanalgorithm }%
292 \def\xinteuclideanalgorithm #1%
293 {%
294 \expandafter \XINT_euc \expandafter{\romannumeral0\xintiabs {#1}}%
295 }%
296 \def\XINT_euc #1#2%
297 {%
298 \expandafter\XINT_euc_fork \romannumeral0\xintiabs {#2}\Z #1\Z
299 }%

```

Ici  $\#3\#4=A$ ,  $\#1\#2=B$

```

300 \def\XINT_euc_fork #1#2\Z #3#4\Z
301 {%
302 \xint_UDzerofork
303 #1\XINT_euc_BisZero
304 #3\XINT_euc_AisZero
305 0\XINT_euc_a
306 \kroft
307 {0}{#1#2}{#3#4}{#3#4}{#1#2}}{\Z
308 }%

```

Le  $\{\}$  pour protéger  $\{\{A\}\{B\}\}$  si on s'arrête après une étape ( $B$  divise  $A$ ). On va renvoyer:

$\{N\}\{A\}\{D=r(n)\}\{B\}\{q_1\}\{r_1\}\{q_2\}\{r_2\}\{q_3\}\{r_3\}\dots\{q_N\}\{r_N=0\}$

```

309 \def\XINT_euc_AisZero #1#2#3#4#5#6{ {1}{0}{#2}{#2}{0}{0}}%
310 \def\XINT_euc_BisZero #1#2#3#4#5#6{ {1}{0}{#3}{#3}{0}{0}}%

```

$\{n\}\{r_n\}\{a_n\}\{q_n\}\{r_n\}\dots\{\{A\}\{B\}\}\{\}\Z$   
 $a(n) = r(n-1)$ . Pour  $n=0$  on a juste  $\{0\}\{B\}\{A\}\{\{A\}\{B\}\}\{\}\Z$   
 $\backslash\text{XINT\_div\_prepare } \{u\}\{v\}$  divise  $v$  par  $u$

```

311 \def\XINT_euc_a #1#2#3%

```

```

312 {%
313   \expandafter\XINT_euc_b
314   \expandafter {\the\numexpr #1+1\expandafter }%
315   \romannumeral0\XINT_div_prepare {#2}{#3}{#2}%
316 }%

{n+1}{q(n+1)}{r(n+1)}{rn}{{qn}{rn}}...

317 \def\XINT_euc_b #1#2#3#4%
318 {%
319   \XINT_euc_c #3\Z {#1}{#3}{#4}{{#2}{#3}}%
320 }%

r(n+1)\Z {n+1}{r(n+1)}{r(n)}{{q(n+1)}{r(n+1)}}{{qn}{rn}}...
Test si r(n+1) est nul.

321 \def\XINT_euc_c #1#2\Z
322 {%
323   \xint_gob_til_zero #1\xint_euc_end0\XINT_euc_a
324 }%

{n+1}{r(n+1)}{r(n)}{{q(n+1)}{r(n+1)}}...{\Z Ici r(n+1) = 0. On arrête on se
prépare à inverser {n+1}{0}{r(n)}{{q(n+1)}{r(n+1)}}...{{q1}{r1}}{{A}{B}}{\Z
On veut renvoyer: {N=n+1}{A}{D=r(n)}{B}{q1}{r1}{q2}{r2}{q3}{r3}...{qN}{rN=0}}

325 \def\xint_euc_end0\XINT_euc_a #1#2#3#4\Z%
326 {%
327   \expandafter\xint_euc_end_
328   \romannumeral0%
329   \XINT_rord_main {#4}{#1}{#3}}%
330   \xint_relax
331   \xint_bye\xint_bye\xint_bye\xint_bye
332   \xint_bye\xint_bye\xint_bye\xint_bye
333   \xint_relax
334 }%
335 \edef\xint_euc_end_ #1#2#3%
336 {%
337   \space {#1}{#3}{#2}%
338 }%

```

### 38.11 \xintBezoutAlgorithm

Pour Bezout: objectif, renvoyer

```

{N}{A}{0}{1}{D=r(n)}{B}{1}{0}{q1}{r1}{alpha1=q1}{beta1=1}
{q2}{r2}{alpha2}{beta2}...{qN}{rN=0}{alphaN=A/D}{betaN=B/D}
alpha0=1, beta0=0, alpha(-1)=0, beta(-1)=1

```

```

339 \def\xintBezoutAlgorithm {\romannumeral0\xintbezoutalgorithm }%
340 \def\xintbezoutalgorithm #1%
341 {%

```

```

342 \expandafter \XINT_bezalg \expandafter{\romannumeral0\xintiabs {#1}}%
343}%
344 \def\XINT_bezalg #1#2%
345 {%
346 \expandafter\XINT_bezalg_fork \romannumeral0\xintiabs {#2}\Z #1\Z
347}%

Ici #3#4=A, #1#2=B

348 \def\XINT_bezalg_fork #1#2\Z #3#4\Z
349 {%
350 \xint_UDzerofork
351 #1\XINT_bezalg_BisZero
352 #3\XINT_bezalg_AisZero
353 0\XINT_bezalg_a
354 \krof
355 0{#1#2}{#3#4}1001{{#3#4}{#1#2}}{\Z
356}%
357 \def\XINT_bezalg_AisZero #1#2#3\Z{ {1}{0}{0}{1}{#2}{#2}{1}{0}{0}{0}{0}{1}}%
358 \def\XINT_bezalg_BisZero #1#2#3#4\Z{ {1}{0}{0}{1}{#3}{#3}{1}{0}{0}{0}{0}{1}}%

pour préparer l'étape n+1 il faut {n}{r(n)}{r(n-1)}{alpha(n)}{beta(n)}{alpha(n-
1)}{beta(n-1)}{{q(n)}{r(n)}{alpha(n)}{beta(n)}}... division de #3 par #2

359 \def\XINT_bezalg_a #1#2#3%
360 {%
361 \expandafter\XINT_bezalg_b
362 \expandafter {\the\numexpr #1+1\expandafter}%
363 \romannumeral0\XINT_div_prepare {#2}{#3}{#2}%
364}%

{n+1}{q(n+1)}{r(n+1)}{r(n)}{alpha(n)}{beta(n)}{alpha(n-1)}{beta(n-1)}...

365 \def\XINT_bezalg_b #1#2#3#4#5#6#7#8%
366 {%
367 \expandafter\XINT_bezalg_c\expandafter
368 {\romannumeral0\xintiiadd {\xintiiMul {#6}{#2}}{#8}}%
369 {\romannumeral0\xintiiadd {\xintiiMul {#5}{#2}}{#7}}%
370 {#1}{#2}{#3}{#4}{#5}{#6}%
371}%

{beta(n+1)}{alpha(n+1)}{n+1}{q(n+1)}{r(n+1)}{r(n)}{alpha(n)}{beta(n)}

372 \def\XINT_bezalg_c #1#2#3#4#5#6%
373 {%
374 \expandafter\XINT_bezalg_d\expandafter {#2}{#3}{#4}{#5}{#6}{#1}%
375}%

{alpha(n+1)}{n+1}{q(n+1)}{r(n+1)}{r(n)}{beta(n+1)}

376 \def\XINT_bezalg_d #1#2#3#4#5#6#7#8%

```

```

377 {%
378   \XINT_bezalg_e #4\Z {#2}{#4}{#5}{#1}{#6}{#7}{#8}{#3}{#4}{#1}{#6}}%
379}%

r(n+1)\Z {n+1}{r(n+1)}{r(n)}{alpha(n+1)}{beta(n+1)}
{alpha(n)}{beta(n)}{q,r,alpha,beta(n+1)}
Test si r(n+1) est nul.

380 \def\XINT_bezalg_e #1#2\Z
381 {%
382   \xint_gob_til_zero #1\xint_bezalg_end0\XINT_bezalg_a
383}%

Ici r(n+1) = 0. On arrête on se prépare à inverser.
{n+1}{r(n+1)}{r(n)}{alpha(n+1)}{beta(n+1)}{alpha(n)}{beta(n)}
{q,r,alpha,beta(n+1)}...{A}{B}}\Z
On veut renvoyer
{N}{A}{0}{1}{D=r(n)}{B}{1}{0}{q1}{r1}{alpha1=q1}{beta1=1}
{q2}{r2}{alpha2}{beta2}...{qN}{rN=0}{alphaN=A/D}{betaN=B/D}

384 \def\xint_bezalg_end0\XINT_bezalg_a #1#2#3#4#5#6#7#8\Z
385 {%
386   \expandafter\xint_bezalg_end_
387   \romannumeral0%
388   \XINT_rord_main {}#8{{#1}{#3}}%
389   \xint_relax
390   \xint_bye\xint_bye\xint_bye\xint_bye
391   \xint_bye\xint_bye\xint_bye\xint_bye
392   \xint_relax
393}%

{N}{D}{A}{B}{q1}{r1}{alpha1=q1}{beta1=1}{q2}{r2}{alpha2}{beta2}
...{qN}{rN=0}{alphaN=A/D}{betaN=B/D}
On veut renvoyer
{N}{A}{0}{1}{D=r(n)}{B}{1}{0}{q1}{r1}{alpha1=q1}{beta1=1}
{q2}{r2}{alpha2}{beta2}...{qN}{rN=0}{alphaN=A/D}{betaN=B/D}

394 \edef\xint_bezalg_end_ #1#2#3#4%
395 {%
396   \space {#1}{#3}{0}{1}{#2}{#4}{1}{0}%
397}%

```

### 38.12 \xintTypesetEuclideanAlgorithm

#### TYPESETTING

Organisation:

$\{N\}\{A\}\{D\}\{B\}\{q_1\}\{r_1\}\{q_2\}\{r_2\}\{q_3\}\{r_3\}\dots\{q_N\}\{r_N=0\}$   
 $\backslash U1 = N = \text{nombre d'étapes}, \backslash U3 = \text{PGCD}, \backslash U2 = A, \backslash U4=B \quad q_1 = \backslash U5, q_2 = \backslash U7 \rightarrow q_n =$   
 $\backslash U<2n+3>, r_n = \backslash U<2n+4> \quad b_n = r_n. \quad B = r_0. \quad A=r(-1)$   
 $r(n-2) = q(n)r(n-1)+r(n) \quad (n \text{ e étape})$

```

\U{2n} = \U{2n+3} \times \U{2n+2} + \U{2n+4}, n e étape. (avec n entre 1 et N)
1.09h uses \xintloop, and \par rather than \endgraf; and \par rather than
\hfill\break

398 \def\xintTypesetEuclideanAlgorithm #1#2%
399 {% l'algo remplace #1 et #2 par |#1| et |#2|
400   \par
401   \beginingroup
402     \xintAssignArray\xintEuclideanAlgorithm {#1}{#2}\to\U
403     \edef\A{\U2}\edef\B{\U4}\edef\N{\U1}%
404     \setbox 0 \vbox{\halign {$##$\cr \A\cr \B \cr}}%
405     \count 255 1
406     \xintloop
407       \indent\hbox to \wd 0 {\hfil$\U{\numexpr 2*\count255\relax}$}%
408       ${} = \U{\numexpr 2*\count255 + 3\relax}
409       \times \U{\numexpr 2*\count255 + 2\relax}
410       + \U{\numexpr 2*\count255 + 4\relax}$%
411       \ifnum \count255 < \N
412         \par
413         \advance \count255 1
414       \repeat
415     \endgroup
416 }%

```

### 38.13 \xintTypesetBezoutAlgorithm

Pour Bezout on a:  $\{N\}\{A\}\{0\}\{1\}\{D=r(n)\}\{B\}\{1\}\{0\}\{q_1\}\{r_1\}\{\alpha_1=q_1\}\{\beta_1=1\}$   
 $\{q_2\}\{r_2\}\{\alpha_2\}\{\beta_2\}\dots\{q_N\}\{r_N=0\}\{\alpha_N=A/D\}\{\beta_N=B/D\}$  Donc  $4N+8$  ter-  
mes:  $U_1 = N$ ,  $U_2 = A$ ,  $U_5 = D$ ,  $U_6 = B$ ,  $q_1 = U_9$ ,  $q_n = U_{4n+5}$ ,  $n$  au moins 1  
 $r_n = U_{4n+6}$ ,  $n$  au moins -1  
 $\alpha(n) = U_{4n+7}$ ,  $n$  au moins -1  
 $\beta(n) = U_{4n+8}$ ,  $n$  au moins -1  
1.09h uses \xintloop, and \par rather than \endgraf; and no more \parindent0pt

```

417 \def\xintTypesetBezoutAlgorithm #1#2%
418 {%
419   \par
420   \beginingroup
421     \xintAssignArray\xintBezoutAlgorithm {#1}{#2}\to\BEZ
422     \edef\A{\BEZ2}\edef\B{\BEZ6}\edef\N{\BEZ1}% A = |#1|, B = |#2|
423     \setbox 0 \vbox{\halign {$##$\cr \A\cr \B \cr}}%
424     \count255 1
425     \xintloop
426       \indent\hbox to \wd 0 {\hfil$\BEZ{4*\count255 - 2}$}%
427       ${} = \BEZ{4*\count255 + 5}
428       \times \BEZ{4*\count255 + 2}
429       + \BEZ{4*\count255 + 6}$\hfill\break
430       \hbox to \wd 0 {\hfil$\BEZ{4*\count255 + 7}$}%
431       ${} = \BEZ{4*\count255 + 5}

```

```

432 \times \BEZ{4*\count255 + 3}
433 + \BEZ{4*\count255 - 1}$\hfill\break
434 \hbox to \wd 0 {\hfil$\BEZ{4*\count255 +8}$}%
435 $\} = \BEZ{4*\count255 + 5}
436 \times \BEZ{4*\count255 + 4}
437 + \BEZ{4*\count255 }$
438 \par
439 \ifnum \count255 < \N
440 \advance \count255 1
441 \repeat
442 \edefU{\BEZ{4*\N + 4}}%
443 \edefV{\BEZ{4*\N + 3}}%
444 \edefD{\BEZ5}%
445 \ifodd\N
446 $U\times A - V\times B = -D$%
447 \else
448 $U\times A - V\times B = D$%
449 \fi
450 \par
451 \endgroup
452 }%

```

### 38.14 \xintGCDof:csv

1.09a. For use by \xintexpr.

```

453 \def\xintGCDof:csv #1{\expandafter\XINT_gcdof:_b\romannumeral-‘0#1,,}%
454 \def\XINT_gcdof:_b #1,#2,{\expandafter\XINT_gcdof:_c\romannumeral-‘0#2,{#1},}%
455 \def\XINT_gcdof:_c #1{\if #1,\expandafter\XINT_of:_e
456 \else\expandafter\XINT_gcdof:_d\fi #1}%
457 \def\XINT_gcdof:_d #1,{\expandafter\XINT_gcdof:_b\romannumeral0\xintgcd {#1}}%

```

### 38.15 \xintLCMof:csv

1.09a. For use by \xintexpr.

```

458 \def\xintLCMof:csv #1{\expandafter\XINT_lcmof:_a\romannumeral-‘0#1,,}%
459 \def\XINT_lcmof:_a #1,#2,{\expandafter\XINT_lcmof:_c\romannumeral-‘0#2,{#1},}%
460 \def\XINT_lcmof:_c #1{\if#1,\expandafter\XINT_of:_e
461 \else\expandafter\XINT_lcmof:_d\fi #1}%
462 \def\XINT_lcmof:_d #1,{\expandafter\XINT_lcmof:_a\romannumeral0\xintlcm {#1}}%
463 \XINT_restorecatcodes_endinput%

```

## 39 Package **xintfrac** implementation

The commenting is currently (2014/01/09) very sparse.

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.14	\xintFloor .....	304	.52	\xintAbs .....	339
.15	\xintCeil .....	304	.53	\xintOpp .....	340
.16	\xintNumerator .....	305	.54	\xintSgn .....	340
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.20	\xintFwOver .....	306	.58	\xintFloatDiv, \XINTinFloatDiv ..	342
.21	\xintSignedFwOver .....	307	.59	\XINTinFloatSum .....	343
.22	\xintREZ .....	308	.60	\XINTinFloatPrd .....	343
.23	\xintE .....	308	.61	\xintFloatPow, \XINTinFloatPow ..	344
.24	\xintIrr .....	310	.62	\xintFloatPower, \XINTinFloatPower	347
.25	\xintNum .....	311	.63	\xintFloatSqrt, \XINTinFloatSqrt ..	349
.26	\xintifInt .....	312	.64	\XINTinFloatMaxof .....	353
.27	\xintJrr .....	312	.65	\XINTinFloatMinof .....	353
.28	\xintTFrac .....	313	.66	\xintRound:csv .....	353
.29	\XINTinFloatFrac .....	314	.67	\xintFloat:csv .....	354
.30	\xintTrunc, \xintiTrunc .....	314	.68	\xintSum:csv .....	354
.31	\xintRound, \xintiRound .....	316	.69	\xintPrd:csv .....	354
.32	\xintXTrunc .....	318	.70	\xintMaxof:csv .....	355
.33	\xintDigits .....	323	.71	\xintMinof:csv .....	355
.34	\xintFloat .....	324	.72	\XINTinFloatMinof:csv .....	355
.35	\XINTinFloat .....	327	.73	\XINTinFloatMaxof:csv .....	355
.36	\xintAdd .....	330	.74	\XINTinFloatSum:csv .....	356
.37	\xintSub .....	330	.75	\XINTinFloatPrd:csv .....	356
.38	\xintSum .....	331			

### 39.1 Catcodes, $\varepsilon$ -TeX and reload detection

The code for reload detection is copied from HEIKO OBERDIEK's packages, and adapted here to check for previous loading of the master *xint* package.

The method for catcodes is slightly different, but still directly inspired by these packages.

```

1 \begingroup\catcode61\catcode48\catcode32=10\relax%
2 \catcode13=5 % ^^M
3 \endlinechar=13 %
4 \catcode123=1 % {
5 \catcode125=2 % }
6 \catcode64=11 % @
7 \catcode35=6 % #
8 \catcode44=12 % ,
9 \catcode45=12 % -
10 \catcode46=12 % .
11 \catcode58=12 % :
12 \def\space { }%
13 \let\z\endgroup
14 \expandafter\let\expandafter\x\csname ver@xintfrac.sty\endcsname
15 \expandafter\let\expandafter\w\csname ver@xint.sty\endcsname
16 \expandafter
17 \ifx\csname PackageInfo\endcsname\relax
18 \def\y#1#2{\immediate\write-1{Package #1 Info: #2.}}%
19 \else
20 \def\y#1#2{\PackageInfo{#1}{#2}}%
21 \fi
22 \expandafter
23 \ifx\csname numexpr\endcsname\relax
24 \y{xintfrac}{\numexpr not available, aborting input}%
25 \aftergroup\endinput
26 \else
27 \ifx\x\relax % plain-TeX, first loading of xintfrac.sty
28 \ifx\w\relax % but xint.sty not yet loaded.
29 \y{xintfrac}{now issuing \string\input\space xint.sty}%
30 \def\z{\endgroup\input xint.sty\relax}%
31 \fi
32 \else
33 \def\empty {}%
34 \ifx\x\empty % LaTeX, first loading,
35 % variable is initialized, but \ProvidesPackage not yet seen
36 \ifx\w\relax % xint.sty not yet loaded.
37 \y{xintfrac}{now issuing \string\RequirePackage{xint}}%
38 \def\z{\endgroup\RequirePackage{xint}}%
39 \fi
40 \else
41 \y{xintfrac}{I was already loaded, aborting input}%
42 \aftergroup\endinput
43 \fi
44 \fi

```

```

45 \fi
46 \z%
```

### 39.2 Confirmation of *xint* loading

```

47 \begingroup\catcode61\catcode48\catcode32=10\relax%
48 \catcode13=5 % ^^M
49 \endlinechar=13 %
50 \catcode123=1 % {
51 \catcode125=2 % }
52 \catcode64=11 % @
53 \catcode35=6 % #
54 \catcode44=12 % ,
55 \catcode45=12 % -
56 \catcode46=12 % .
57 \catcode58=12 % :
58 \ifdefined\PackageInfo
59 \def\y#1#2{\PackageInfo{#1}{#2}}%
60 \else
61 \def\y#1#2{\immediate\write-1{Package #1 Info: #2.}}%
62 \fi
63 \def\empty {}%
64 \expandafter\let\expandafter\w\csname ver@xint.sty\endcsname
65 \ifx\w\relax % Plain TeX, user gave a file name at the prompt
66 \y{xintfrac}{Loading of package xint failed, aborting input}%
67 \aftergroup\endinput
68 \fi
69 \ifx\w\empty % LaTeX, user gave a file name at the prompt
70 \y{xintfrac}{Loading of package xint failed, aborting input}%
71 \aftergroup\endinput
72 \fi
73 \endgroup%
```

### 39.3 Catcodes

```

74 \XINTsetupcatcodes%
```

### 39.4 Package identification

```

75 \XINT_providespackage
76 \ProvidesPackage{xintfrac}%
77 [2014/01/09 v1.09j Expandable operations on fractions (jfb)]%
78 \chardef\xint_c_vi 6
79 \chardef\xint_c_vii 7
80 \chardef\xint_c_xviii 18
```

### 39.5 *\xintLen*

```

81 \def\xintLen {\romannumeral0\xintlen}%
82 \def\xintlen #1%
83 {%
```

```

84 \expandafter\XINT_flen\romannumeral0\XINT_infrac {#1}%
85 }%
86 \def\XINT_flen #1#2#3%
87 {%
88 \expandafter\space
89 \the\numexpr -1+\XINT_Abs {#1}+\XINT_Len {#2}+\XINT_Len {#3}\relax
90 }%

```

### 39.6 \XINT\_lenrord\_loop

```

91 \def\XINT_lenrord_loop #1#2#3#4#5#6#7#8#9%
92 {% faire \romannumeral-‘0\XINT_lenrord_loop 0{ }#1\Z\W\W\W\W\W\W\W\Z
93 \xint_gob_til_W #9\XINT_lenrord_W\W
94 \expandafter\XINT_lenrord_loop\expandafter
95 {\the\numexpr #1+7}{#9#8#7#6#5#4#3#2}%
96 }%
97 \def\XINT_lenrord_W\W\expandafter\XINT_lenrord_loop\expandafter #1#2#3\Z
98 {%
99 \expandafter\XINT_lenrord_X\expandafter {#1}#2\Z
100 }%
101 \def\XINT_lenrord_X #1#2\Z
102 {%
103 \XINT_lenrord_Y #2\R\R\R\R\R\R\T {#1}%
104 }%
105 \def\XINT_lenrord_Y #1#2#3#4#5#6#7#8\T
106 {%
107 \xint_gob_til_W
108 #7\XINT_lenrord_Z \xint_c_viii
109 #6\XINT_lenrord_Z \xint_c_vii
110 #5\XINT_lenrord_Z \xint_c_vi
111 #4\XINT_lenrord_Z \xint_c_v
112 #3\XINT_lenrord_Z \xint_c_iv
113 #2\XINT_lenrord_Z \xint_c_iii
114 \W\XINT_lenrord_Z \xint_c_ii \Z
115 }%
116 \def\XINT_lenrord_Z #1#2\Z #3% retourne: {longueur}renverse\Z
117 {%
118 \expandafter{\the\numexpr #3-#1\relax}%
119 }%

```

### 39.7 \XINT\_outfrac

1.06a version now outputs 0/1[0] and not 0[0] in case of zero. More generally all macros have been checked in xintfrac, xintseries, xintcfrac, to make sure the output format for fractions was always A/B[n]. (except \xintIrr, \xintJrr, \xintRawWithZeros)

The problem with statements like those in the previous paragraph is that it is hard to maintain consistencies across releases.

```

120 \def\XINT_outfrac #1#2#3%

```

```

121 {%
122   \ifcase\XINT_cntSgn #3\Z
123     \expandafter \XINT_outfrac_divisionbyzero
124   \or
125     \expandafter \XINT_outfrac_P
126   \else
127     \expandafter \XINT_outfrac_N
128   \fi
129   {#2}{#3}[#1]%
130 }%
131 \def\XINT_outfrac_divisionbyzero #1#2{\xintError:DivisionByZero\space #1/0}%
132 \edef\XINT_outfrac_P #1#2%
133 {%
134   \noexpand\if0\noexpand\XINT_Sgn #1\noexpand\Z
135     \noexpand\expandafter\noexpand\XINT_outfrac_Zero
136   \noexpand\fi
137   \space #1/#2%
138 }%
139 \def\XINT_outfrac_Zero #1[#2]{ 0/1[0]}%
140 \def\XINT_outfrac_N #1#2%
141 {%
142   \expandafter\XINT_outfrac_N_a\expandafter
143   {\romannumeral0\XINT_opp #2}{\romannumeral0\XINT_opp #1}%
144 }%
145 \def\XINT_outfrac_N_a #1#2%
146 {%
147   \expandafter\XINT_outfrac_P\expandafter {#2}{#1}%
148 }%

```

### 39.8 \XINT\_inFrac

Extended in 1.07 to accept scientific notation on input. With lowercase e only.  
The \xintexpr parser does accept uppercase E also.

```

149 \def\XINT_inFrac {\romannumeral0\XINT_infrac }%
150 \def\XINT_infrac #1%
151 {%
152   \expandafter\XINT_infrac_ \romannumeral- '0#1[\W]\Z\T
153 }%
154 \def\XINT_infrac_ #1[#2#3]#4\Z
155 {%
156   \xint_UDwfork
157     #2\XINT_infrac_A
158   \W\XINT_infrac_B
159   \krof
160   #1[#2#3]#4%
161 }%
162 \def\XINT_infrac_A #1[\W]\T
163 {%

```

```

164 \XINT_frac #1/\W\Z
165 }%
166 \def\XINT_infrac_B #1%
167 {%
168 \xint_gob_til_zero #1\XINT_infrac_Zero0\XINT_infrac_BB #1%
169 }%
170 \def\XINT_infrac_BB #1[\W]\T {\XINT_infrac_BC #1/\W\Z }%
171 \def\XINT_infrac_BC #1/#2#3\Z
172 {%
173 \xint_UDwfork
174 #2\XINT_infrac_BCa
175 \W{\expandafter\XINT_infrac_BCb \romannumeral-‘0#2}%
176 \krof
177 #3\Z #1\Z
178 }%
179 \def\XINT_infrac_BCa \Z #1[#2]#3\Z { {#2}{#1}{1}}%
180 \def\XINT_infrac_BCb #1[#2]/\W\Z #3\Z { {#2}{#3}{#1}}%
181 \def\XINT_infrac_Zero #1\T { {0}{0}{1}}%

```

### 39.9 \XINT\_frac

Extended in 1.07 to recognize and accept scientific notation both at the numerator and (possible) denominator. Only a lowercase e will do here, but uppercase E is possible within an \xintexpr..\relax

```

182 \def\XINT_frac #1/#2#3\Z
183 {%
184 \xint_UDwfork
185 #2\XINT_frac_A
186 \W{\expandafter\XINT_frac_U \romannumeral-‘0#2}%
187 \krof
188 #3e\W\Z #1e\W\Z
189 }%
190 \def\XINT_frac_U #1e#2#3\Z
191 {%
192 \xint_UDwfork
193 #2\XINT_frac_Ua
194 \W{\XINT_frac_Ub #2}%
195 \krof
196 #3\Z #1\Z
197 }%
198 \def\XINT_frac_Ua \Z #1/\W\Z {\XINT_frac_B #1.\W\Z {0}}%
199 \def\XINT_frac_Ub #1/\W e\W\Z #2\Z {\XINT_frac_B #2.\W\Z {#1}}%
200 \def\XINT_frac_B #1.#2#3\Z
201 {%
202 \xint_UDwfork
203 #2\XINT_frac_Ba
204 \W{\XINT_frac_Bb #2}%
205 \krof

```

```

206      #3\Z #1\Z
207 }%
208 \def\XINT_frac_Ba \Z #1\Z {\XINT_frac_T {0}{#1}}%
209 \def\XINT_frac_Bb #1.\W\Z #2\Z
210 {%
211     \expandafter \XINT_frac_T \expandafter
212     {\romannumeral0\xintlength {#1}}{#2#1}%
213 }%
214 \def\XINT_frac_A e\W\Z {\XINT_frac_T {0}{1}{0}}%
215 \def\XINT_frac_T #1#2#3#4e#5#6\Z
216 {%
217     \xint_UDwfork
218     #5\XINT_frac-Ta
219     \W{\XINT_frac-Tb #5}%
220     \krof
221     #6\Z #4\Z {#1}{#2}{#3}%
222 }%
223 \def\XINT_frac-Ta \Z #1\Z {\XINT_frac_C #1.\W\Z {0}}%
224 \def\XINT_frac-Tb #1e\W\Z #2\Z {\XINT_frac_C #2.\W\Z {#1}}%
225 \def\XINT_frac_C #1.#2#3\Z
226 {%
227     \xint_UDwfork
228     #2\XINT_frac-Ca
229     \W{\XINT_frac-Cb #2}%
230     \krof
231     #3\Z #1\Z
232 }%
233 \def\XINT_frac_Ca \Z #1\Z {\XINT_frac_D {0}{#1}}%
234 \def\XINT_frac_Cb #1.\W\Z #2\Z
235 {%
236     \expandafter\XINT_frac_D\expandafter
237     {\romannumeral0\xintlength {#1}}{#2#1}%
238 }%
239 \def\XINT_frac_D #1#2#3#4#5#6%
240 {%
241     \expandafter \XINT_frac_E \expandafter
242     {\the\numexpr -#1+#3+#4-#6\expandafter}\expandafter
243     {\romannumeral0\XINT_num_loop #2%
244     \xint_relax\xint_relax\xint_relax\xint_relax
245     \xint_relax\xint_relax\xint_relax\xint_relax\Z }%
246     {\romannumeral0\XINT_num_loop #5%
247     \xint_relax\xint_relax\xint_relax\xint_relax
248     \xint_relax\xint_relax\xint_relax\xint_relax\Z }%
249 }%
250 \def\XINT_frac_E #1#2#3%
251 {%
252     \expandafter \XINT_frac_F #3\Z {#2}{#1}%
253 }%
254 \def\XINT_frac_F #1%

```

```

255 {%
256   \xint_UDzerominusfork
257   #1-\XINT_frac_Gdivisionbyzero
258   0#1\XINT_frac_Gneg
259   0-{\XINT_frac_Gpos #1}%
260   \krof
261 }%
262 \edef\XINT_frac_Gdivisionbyzero #1\Z #2#3%
263 {%
264   \noexpand\xintError:DivisionByZero\space {0}{#2}{0}%
265 }%
266 \def\XINT_frac_Gneg #1\Z #2#3%
267 {%
268   \expandafter\XINT_frac_H \expandafter{\romannumeral0\XINT_opp #2}{#3}{#1}%
269 }%
270 \def\XINT_frac_H #1#2{ {#2}{#1}}%
271 \def\XINT_frac_Gpos #1\Z #2#3{ {#3}{#2}{#1}}%

```

### 39.10 \XINT\_factortens, \XINT\_cuz\_cnt

```

272 \def\XINT_factortens #1%
273 {%
274   \expandafter\XINT_cuz_cnt_loop\expandafter
275   {\expandafter}\romannumeral0\XINT_rord_main { }#1%
276   \xint_relax
277   \xint_bye\xint_bye\xint_bye\xint_bye
278   \xint_bye\xint_bye\xint_bye\xint_bye
279   \xint_relax
280   \R\R\R\R\R\R\R\R\Z
281 }%
282 \def\XINT_cuz_cnt #1%
283 {%
284   \XINT_cuz_cnt_loop { }#1\R\R\R\R\R\R\R\R\Z
285 }%
286 \def\XINT_cuz_cnt_loop #1#2#3#4#5#6#7#8#9%
287 {%
288   \xint_gob_til_R #9\XINT_cuz_cnt_toofara \R
289   \expandafter\XINT_cuz_cnt_checka\expandafter
290   {\the\numexpr #1+8\relax}{#2#3#4#5#6#7#8#9}%
291 }%
292 \def\XINT_cuz_cnt_toofara\R
293   \expandafter\XINT_cuz_cnt_checka\expandafter #1#2%
294 {%
295   \XINT_cuz_cnt_toofarb {#1}#2%
296 }%
297 \def\XINT_cuz_cnt_toofarb #1#2\Z {\XINT_cuz_cnt_toofarc #2\Z {#1}}%
298 \def\XINT_cuz_cnt_toofarc #1#2#3#4#5#6#7#8%
299 {%
300   \xint_gob_til_R #2\XINT_cuz_cnt_toofard 7%

```

### 39 Package *xintfrac* implementation

```

301          #3\XINT_cuz_cnt_toofard 6%
302          #4\XINT_cuz_cnt_toofard 5%
303          #5\XINT_cuz_cnt_toofard 4%
304          #6\XINT_cuz_cnt_toofard 3%
305          #7\XINT_cuz_cnt_toofard 2%
306          #8\XINT_cuz_cnt_toofard 1%
307          \Z #1#2#3#4#5#6#7#8%
308 }%
309 \def\XINT_cuz_cnt_toofard #1#2\Z #3\R #4\Z #5%
310 {%
311   \expandafter\XINT_cuz_cnt_toofare
312   \the\numexpr #3\relax \R\R\R\R\R\R\R\R\Z
313   {\the\numexpr #5-#1\relax}\R\Z
314 }%
315 \def\XINT_cuz_cnt_toofare #1#2#3#4#5#6#7#8%
316 {%
317   \xint_gob_til_R #2\XINT_cuz_cnt_stopc 1%
318   #3\XINT_cuz_cnt_stopc 2%
319   #4\XINT_cuz_cnt_stopc 3%
320   #5\XINT_cuz_cnt_stopc 4%
321   #6\XINT_cuz_cnt_stopc 5%
322   #7\XINT_cuz_cnt_stopc 6%
323   #8\XINT_cuz_cnt_stopc 7%
324   \Z #1#2#3#4#5#6#7#8%
325 }%
326 \def\XINT_cuz_cnt_checka #1#2%
327 {%
328   \expandafter\XINT_cuz_cnt_checkb\the\numexpr #2\relax \Z {#1}%
329 }%
330 \def\XINT_cuz_cnt_checkb #1%
331 {%
332   \xint_gob_til_zero #1\expandafter\XINT_cuz_cnt_loop\xint_gob_til_Z
333   0\XINT_cuz_cnt_stopa #1%
334 }%
335 \def\XINT_cuz_cnt_stopa #1\Z
336 {%
337   \XINT_cuz_cnt_stopb #1\R\R\R\R\R\R\R\R\Z %
338 }%
339 \def\XINT_cuz_cnt_stopb #1#2#3#4#5#6#7#8#9%
340 {%
341   \xint_gob_til_R #2\XINT_cuz_cnt_stopc 1%
342   #3\XINT_cuz_cnt_stopc 2%
343   #4\XINT_cuz_cnt_stopc 3%
344   #5\XINT_cuz_cnt_stopc 4%
345   #6\XINT_cuz_cnt_stopc 5%
346   #7\XINT_cuz_cnt_stopc 6%
347   #8\XINT_cuz_cnt_stopc 7%
348   #9\XINT_cuz_cnt_stopc 8%
349   \Z #1#2#3#4#5#6#7#8#9%

```

```

350 }%
351 \def\XINT_cuz_cnt_stopc #1#2\Z #3\R #4\Z #5%
352 {%
353   \expandafter\XINT_cuz_cnt_stopd\expandafter
354   {\the\numexpr #5-#1}\#3%
355 }%
356 \def\XINT_cuz_cnt_stopd #1#2\R #3\Z
357 {%
358   \expandafter\space\expandafter
359   {\romannumeral0\XINT_rord_main {}}\#2%
360   \xint_relax
361   \xint_bye\xint_bye\xint_bye\xint_bye
362   \xint_bye\xint_bye\xint_bye\xint_bye
363   \xint_relax }\#1}%
364 }%

```

### 39.11 \xintRaw

1.07: this macro simply prints in a user readable form the fraction after its initial scanning. Useful when put inside braces in an `\xintexpr`, when the input is not yet in the  $A/B[n]$  form.

```

365 \def\xintRaw {\romannumeral0\xintraw }%
366 \def\xintraw
367 {%
368   \expandafter\XINT_raw\romannumeral0\XINT_infrac
369 }%
370 \def\XINT_raw #1#2#3{ #2/#3[#1]}%

```

### 39.12 \xintPraw

1.09b: these `[n]`'s and especially the possible `/1` are truly annoying at times.

```

371 \def\xintPraw {\romannumeral0\xintpraw }%
372 \def\xintpraw
373 {%
374   \expandafter\XINT_praw\romannumeral0\XINT_infrac
375 }%
376 \def\XINT_praw #1%
377 {%
378   \ifnum #1=\xint_c_ \expandafter\XINT_praw_a\fi \XINT_praw_A {#1}%
379 }%
380 \def\XINT_praw_A #1#2#3%
381 {%
382   \if\XINT_isOne{#3}1\expandafter\xint_firstoftwo
383   \else\expandafter\xint_secondoftwo
384   \fi { #2[#1]}{ #2/#3[#1]}%
385 }%
386 \def\XINT_praw_a\XINT_praw_A #1#2#3%

```

```

387 {%
388   \if\XINT_isOne{#3}1\expandafter\xint_firstoftwo
389   \else\expandafter\xint_secondoftwo
390   \fi { #2}{ #2/#3}%
391 }%

```

### 39.13 \xintRawWithZeros

This was called \xintRaw in versions earlier than 1.07

```

392 \def\xintRawWithZeros {\romannumeral0\xintrawwithzeros }%
393 \def\xintrawwithzeros
394 {%
395   \expandafter\XINT_rawz\romannumeral0\XINT_infrac
396 }%
397 \def\XINT_rawz #1%
398 {%
399   \ifcase\XINT_cntSgn #1\Z
400     \expandafter\XINT_rawz_Ba
401   \or
402     \expandafter\XINT_rawz_A
403   \else
404     \expandafter\XINT_rawz_Ba
405   \fi
406   {#1}%
407 }%
408 \def\XINT_rawz_A #1#2#3{\xint_dsh {#2}{-#1}/#3}%
409 \def\XINT_rawz_Ba #1#2#3{\expandafter\XINT_rawz_Bb
410   \expandafter{\romannumeral0\xint_dsh {#3}{#1}}{#2}}%
411 \def\XINT_rawz_Bb #1#2{ #2/#1}%

```

### 39.14 \xintFloor

1.09a

```

412 \def\xintFloor {\romannumeral0\xintfloor }%
413 \def\xintfloor #1{\expandafter\XINT_floor
414   \romannumeral0\xintrawwithzeros {#1}.}%
415 \def\XINT_floor #1/#2.{\xintiipro {#1}{#2}}%

```

### 39.15 \xintCeil

1.09a

```

416 \def\xintCeil {\romannumeral0\xintceil }%
417 \def\xintceil #1{\xintiio {#1}{\xintFloor {\xintOpp{#1}}}}%

```

**39.16 \xintNumerator**

```

418 \def\xintNumerator {\romannumeral0\xintnumerator }%
419 \def\xintnumerator
420 {%
421   \expandafter\XINT_numer\romannumeral0\XINT_infrac
422 }%
423 \def\XINT_numer #1%
424 {%
425   \ifcase\XINT_cntSgn #1\Z
426     \expandafter\XINT_numer_B
427   \or
428     \expandafter\XINT_numer_A
429   \else
430     \expandafter\XINT_numer_B
431   \fi
432   {#1}%
433 }%
434 \def\XINT_numer_A #1#2#3{\xint_dsh {#2}{-#1}}%
435 \def\XINT_numer_B #1#2#3{ #2}%

```

**39.17 \xintDenominator**

```

436 \def\xintDenominator {\romannumeral0\xintdenominator }%
437 \def\xintdenominator
438 {%
439   \expandafter\XINT_denom\romannumeral0\XINT_infrac
440 }%
441 \def\XINT_denom #1%
442 {%
443   \ifcase\XINT_cntSgn #1\Z
444     \expandafter\XINT_denom_B
445   \or
446     \expandafter\XINT_denom_A
447   \else
448     \expandafter\XINT_denom_B
449   \fi
450   {#1}%
451 }%
452 \def\XINT_denom_A #1#2#3{ #3}%
453 \def\XINT_denom_B #1#2#3{\xint_dsh {#3}{#1}}%

```

**39.18 \xintFrac**

```

454 \def\xintFrac {\romannumeral0\xintfrac }%
455 \def\xintfrac #1%
456 {%
457   \expandafter\XINT_fracfrac_A\romannumeral0\XINT_infrac {#1}%
458 }%
459 \def\XINT_fracfrac_A #1{\XINT_fracfrac_B #1\Z }%
460 \catcode'\^ =7

```

```

461 \def\XINT_fracfrac_B #1#2\Z
462 {%
463   \xint_gob_til_zero #1\XINT_fracfrac_C 0\XINT_fracfrac_D {10^{#1#2}}}%
464 }%
465 \def\XINT_fracfrac_C 0\XINT_fracfrac_D #1#2#3%
466 {%
467   \if1\XINT_isOne {#3}%
468     \xint_afterfi {\expandafter\xint_firstoftwo_thenstop\xint_gobble_ii }%
469   \fi
470   \space
471   \frac {#2}{#3}%
472 }%
473 \def\XINT_fracfrac_D #1#2#3%
474 {%
475   \if1\XINT_isOne {#3}\XINT_fracfrac_E\fi
476   \space
477   \frac {#2}{#3}#1%
478 }%
479 \def\XINT_fracfrac_E \fi\space\frac #1#2{\fi \space #1\cdot }%

```

**39.19 \xintSignedFrac**

```

480 \def\xintSignedFrac {\romannumeral0\xintsignedfrac }%
481 \def\xintsignedfrac #1%
482 {%
483   \expandafter\XINT_sgnfrac_a\romannumeral0\XINT_infrac {#1}%
484 }%
485 \def\XINT_sgnfrac_a #1#2%
486 {%
487   \XINT_sgnfrac_b #2\Z {#1}%
488 }%
489 \def\XINT_sgnfrac_b #1%
490 {%
491   \xint_UDsignfork
492     #1\XINT_sgnfrac_N
493     -{\XINT_sgnfrac_P #1}%
494   \krof
495 }%
496 \def\XINT_sgnfrac_P #1\Z #2%
497 {%
498   \XINT_fracfrac_A {#2}{#1}%
499 }%
500 \def\XINT_sgnfrac_N
501 {%
502   \expandafter\xint_minus_thenstop\romannumeral0\XINT_sgnfrac_P
503 }%

```

**39.20 \xintFwOver**

```

504 \def\xintFwOver {\romannumeral0\xintfwover }%
505 \def\xintfwover #1%

```

```

506 {%
507   \expandafter\XINT_fwover_A\romannumeral0\XINT_infrac {#1}%
508 }%
509 \def\XINT_fwover_A #1{\XINT_fwover_B #1\Z }%
510 \def\XINT_fwover_B #1#2\Z
511 {%
512   \xint_gob_til_zero #1\XINT_fwover_C 0\XINT_fwover_D {10^{#1#2}}%
513 }%
514 \catcode'\^=11
515 \def\XINT_fwover_C #1#2#3#4#5%
516 {%
517   \if0\XINT_isOne {#5}\xint_afterfi { {#4\over #5}}%
518   \else\xint_afterfi { #4}%
519   \fi
520 }%
521 \def\XINT_fwover_D #1#2#3%
522 {%
523   \if0\XINT_isOne {#3}\xint_afterfi { {#2\over #3}}%
524   \else\xint_afterfi { #2\cdot }%
525   \fi
526   #1%
527 }%

```

### 39.21 \xintSignedFwOver

```

528 \def\xintSignedFwOver {\romannumeral0\xintsignedfwover }%
529 \def\xintsignedfwover #1%
530 {%
531   \expandafter\XINT_sgnfwover_a\romannumeral0\XINT_infrac {#1}%
532 }%
533 \def\XINT_sgnfwover_a #1#2%
534 {%
535   \XINT_sgnfwover_b #2\Z {#1}%
536 }%
537 \def\XINT_sgnfwover_b #1%
538 {%
539   \xint_UDsignfork
540   #1\XINT_sgnfwover_N
541   -{\XINT_sgnfwover_P #1}%
542   \krof
543 }%
544 \def\XINT_sgnfwover_P #1\Z #2%
545 {%
546   \XINT_fwover_A {#2}{#1}%
547 }%
548 \def\XINT_sgnfwover_N
549 {%
550   \expandafter\xint_minus_thenstop\romannumeral0\XINT_sgnfwover_P
551 }%

```

**39.22 \xintREZ**

```

552 \def\xintREZ {\romannumeral0\xintrez }%
553 \def\xintrez
554 {%
555   \expandafter\XINT_rez_A\romannumeral0\XINT_infrac
556 }%
557 \def\XINT_rez_A #1#2%
558 {%
559   \XINT_rez_AB #2\Z {#1}%
560 }%
561 \def\XINT_rez_AB #1%
562 {%
563   \xint_UDzerominusfork
564   #1-\XINT_rez_zero
565   0#1\XINT_rez_neg
566   0-\XINT_rez_B #1}%
567   \krof
568 }%
569 \def\XINT_rez_zero #1\Z #2#3{ 0/1[0]}%
570 \def\XINT_rez_neg {\expandafter\xint_minus_thenstop\romannumeral0\XINT_rez_B }%
571 \def\XINT_rez_B #1\Z
572 {%
573   \expandafter\XINT_rez_C\romannumeral0\XINT_factortens {#1}%
574 }%
575 \def\XINT_rez_C #1#2#3#4%
576 {%
577   \expandafter\XINT_rez_D\romannumeral0\XINT_factortens {#4}{#3}{#2}{#1}%
578 }%
579 \def\XINT_rez_D #1#2#3#4#5%
580 {%
581   \expandafter\XINT_rez_E\expandafter
582   {\the\numexpr #3+#4-#2}{#1}{#5}%
583 }%
584 \def\XINT_rez_E #1#2#3{ #3/#2[#1]}%

```

**39.23 \xintE**

1.07: The fraction is the first argument contrarily to `\xintTrunc` and `\xintRound`. `\xintfE` (1.07) and `\xintiE` (1.09i) are for `\xintexpr` and cousins. It is quite annoying that `\numexpr` does not know how to deal correctly with a minus sign - as prefix: `\numexpr -(1)\relax` is illegal! (one can do `\numexpr 0-(1)\relax`).

the 1.07 `\xintE` puts directly its second argument in a `\numexpr`. The `\xintfE` first uses `\xintNum` on it, this is necessary for use in `\xintexpr`. (but one cannot use directly infix notation in the second argument of `\xintfE`)

1.09i also adds `\xintFloatE` and modifies `\XINTinFloatfE`, although currently the latter is only used from `\xintfloatexpr` hence always with `\XINTdigits`, it comes equipped with its first argument withing brackets as the other `\XINTinFloat...` macros.

```

585 \def\xintE {\romannumeral0\xinte }%
586 \def\xinte #1%
587 {%
588   \expandafter\XINT_e \romannumeral0\XINT_infrac {#1}%
589 }%
590 \def\XINT_e #1#2#3#4%
591 {%
592   \expandafter\XINT_e_end\expandafter{\the\numexpr #1+#4}{#2}{#3}%
593 }%
594 \def\XINT_e_end #1#2#3{ #2/#3[#1]}%
595 \def\xintfE {\romannumeral0\xintfe }%
596 \def\xintfe #1%
597 {%
598   \expandafter\XINT_fe \romannumeral0\XINT_infrac {#1}%
599 }%
600 \def\XINT_fe #1#2#3#4%
601 {%
602   \expandafter\XINT_e_end\expandafter{\the\numexpr #1+\xintNum{#4}}{#2}{#3}%
603 }%
604 \def\xintFloatE {\romannumeral0\xintfloate }%
605 \def\xintfloate #1{\XINT_floate_chkopt #1\Z }%
606 \def\XINT_floate_chkopt #1%
607 {%
608   \ifx [#1\expandafter\XINT_floate_opt
609     \else\expandafter\XINT_floate_noopt
610     \fi #1%
611 }%
612 \def\XINT_floate_noopt #1\Z
613 {%
614   \expandafter\XINT_floate_a\expandafter\XINTdigits
615   \romannumeral0\XINT_infrac {#1}%
616 }%
617 \def\XINT_floate_opt [\Z #1]#2%
618 {%
619   \expandafter\XINT_floate_a\expandafter
620   {\the\numexpr #1\expandafter}\romannumeral0\XINT_infrac {#2}%
621 }%
622 \def\XINT_floate_a #1#2#3#4#5%
623 {%
624   \expandafter\expandafter\expandafter\XINT_float_a
625   \expandafter\xint_exchangetwo_keepbraces\expandafter
626   {\the\numexpr #2+#5}{#1}{#3}{#4}\XINT_float_Q
627 }%
628 \def\XINTinFloatfE {\romannumeral0\XINTinfloatfe }%
629 \def\XINTinfloatfe [#1]#2%
630 {%
631   \expandafter\XINT_infloatfe_a\expandafter
632   {\the\numexpr #1\expandafter}\romannumeral0\XINT_infrac {#2}%
633 }%

```

```

634 \def\XINT_infloatfe_a #1#2#3#4#5%
635 {%
636   \expandafter\expandafter\expandafter\XINT_infloat_a
637   \expandafter\xint_exchangetwo_keepbraces\expandafter
638   {\the\numexpr #2+\xintNum{#5}}{#1}{#3}{#4}\XINT_infloat_Q
639 }%
640 \def\xintiE {\romannumeral0\xintie }% for \xintiexpr only
641 \def\xintie #1%
642 {%
643   \expandafter\XINT_ie \romannumeral0\XINT_infrac {#1}% allows 3.123e3
644 }%
645 \def\XINT_ie #1#2#3#4% assumes #3=1 and uses \xint_dsh with its \numexpr
646 {%
647   \xint_dsh {#2}{0-(#1+#4)}% could have \xintNum{#4} for a bit more general
648 }%

```

### 39.24 \xintIrr

1.04 fixes a buggy `\xintIrr {0}`. 1.05 modifies the initial parsing and post-processing to use `\xintrawithzeros` and to more quickly deal with an input denominator equal to 1. 1.08 version does not remove a /1 denominator.

```

649 \def\xintIrr {\romannumeral0\xintirr }%
650 \def\xintirr #1%
651 {%
652   \expandafter\XINT_irr_start\romannumeral0\xintrawithzeros {#1}\Z
653 }%
654 \def\XINT_irr_start #1#2/#3\Z
655 {%
656   \if0\XINT_isOne {#3}%
657     \xint_afterfi
658     {\xint_UDsignfork
659       #1\XINT_irr_negative
660       -{\XINT_irr_nonneg #1}%
661     \krof}%
662   \else
663     \xint_afterfi{\XINT_irr_denomisone #1}%
664   \fi
665   #2\Z {#3}%
666 }%
667 \def\XINT_irr_denomisone #1\Z #2{ #1/1}% changed in 1.08
668 \def\XINT_irr_negative #1\Z #2{\XINT_irr_D #1\Z #2\Z \xint_minus_thenstop}%
669 \def\XINT_irr_nonneg #1\Z #2{\XINT_irr_D #1\Z #2\Z \space}%
670 \def\XINT_irr_D #1#2\Z #3#4\Z
671 {%
672   \xint_UDzerosfork
673   #3#1\XINT_irr_indeterminate
674   #30\XINT_irr_divisionbyzero
675   #10\XINT_irr_zero

```

```

676      00\XINT_irr_loop_a
677      \krof
678      {#3#4}{#1#2}{#3#4}{#1#2}%
679 }%
680 \def\XINT_irr_indeterminate #1#2#3#4#5{\xintError:NaN\space 0/0}%
681 \def\XINT_irr_divisionbyzero #1#2#3#4#5{\xintError:DivisionByZero #5#2/0}%
682 \def\XINT_irr_zero #1#2#3#4#5{ 0/1}% changed in 1.08
683 \def\XINT_irr_loop_a #1#2%
684 {%
685     \expandafter\XINT_irr_loop_d
686     \romannumeral0\XINT_div_prepare {#1}{#2}{#1}%
687 }%
688 \def\XINT_irr_loop_d #1#2%
689 {%
690     \XINT_irr_loop_e #2\Z
691 }%
692 \def\XINT_irr_loop_e #1#2\Z
693 {%
694     \xint_gob_til_zero #1\xint_irr_loop_exit0\XINT_irr_loop_a {#1#2}%
695 }%
696 \def\xint_irr_loop_exit0\XINT_irr_loop_a #1#2#3#4%
697 {%
698     \expandafter\XINT_irr_loop_exitb\expandafter
699     {\romannumeral0\xintiigo {#3}{#2}}%
700     {\romannumeral0\xintiigo {#4}{#2}}%
701 }%
702 \def\XINT_irr_loop_exitb #1#2%
703 {%
704     \expandafter\XINT_irr_finish\expandafter {#2}{#1}%
705 }%
706 \def\XINT_irr_finish #1#2#3{#3#1/#2}% changed in 1.08

```

### 39.25 \xintNum

This extension of the xint original xintNum is added in 1.05, as a synonym to \xintIrr, but raising an error when the input does not evaluate to an integer. Usable with not too much overhead on integer input as \xintIrr checks quickly for a denominator equal to 1 (which will be put there by the \XINT\_infrac called by \xintrawithzeros). This way, macros such as \xintQuo can be modified with minimal overhead to accept fractional input as long as it evaluates to an integer.

```

707 \def\xintNum {\romannumeral0\xintnum }%
708 \def\xintnum #1{\expandafter\XINT_intcheck\romannumeral0\xintirr {#1}\Z }%
709 \edef\XINT_intcheck #1/#2\Z
710 {%
711     \noexpand\if 0\noexpand\XINT_isOne {#2}\noexpand\xintError:NotAnInteger
712     \noexpand\fi\space #1%
713 }%

```

**39.26 \xintifInt**

1.09e. xintfrac.sty only.

```

714 \def\xintifInt {\romannumeral0\xintifint }%
715 \def\xintifint #1{\expandafter\XINT_ifint\romannumeral0\xintirr {#1}\Z }%
716 \def\XINT_ifint #1/#2\Z
717 {%
718   \if\XINT_isOne {#2}1%
719   \expandafter\xint_firstoftwo_thenstop
720   \else
721   \expandafter\xint_secondoftwo_thenstop
722   \fi
723 }%

```

**39.27 \xintJrr**

Modified similarly as \xintIrr in release 1.05. 1.08 version does not remove a /1 denominator.

```

724 \def\xintJrr {\romannumeral0\xintjrr }%
725 \def\xintjrr #1%
726 {%
727   \expandafter\XINT_jrr_start\romannumeral0\xintrawwithzeros {#1}\Z
728 }%
729 \def\XINT_jrr_start #1#2/#3\Z
730 {%
731   \if0\XINT_isOne {#3}\xint_afterfi
732   {\xint_UDsignfork
733     #1\XINT_jrr_negative
734     -{\XINT_jrr_nonneg #1}%
735     \krof}%
736   \else
737     \xint_afterfi{\XINT_jrr_denomisone #1}%
738   \fi
739   #2\Z {#3}%
740 }%
741 \def\XINT_jrr_denomisone #1\Z #2{ #1/1}% changed in 1.08
742 \def\XINT_jrr_negative #1\Z #2{\XINT_jrr_D #1\Z #2\Z \xint_minus_thenstop }%
743 \def\XINT_jrr_nonneg #1\Z #2{\XINT_jrr_D #1\Z #2\Z \space}%
744 \def\XINT_jrr_D #1#2\Z #3#4\Z
745 {%
746   \xint_UDzerosfork
747   #3#1\XINT_jrr_indeterminate
748   #30\XINT_jrr_divisionbyzero
749   #10\XINT_jrr_zero
750   00\XINT_jrr_loop_a
751   \krof
752   {#3#4}{#1#2}1001%

```

```

753 }%
754 \def\XINT_jrr_indeterminate #1#2#3#4#5#6#7{\xintError:NaN\space 0/0}%
755 \def\XINT_jrr_divisionbyzero #1#2#3#4#5#6#7{\xintError:DivisionByZero #7#2/0}%
756 \def\XINT_jrr_zero #1#2#3#4#5#6#7{ 0/1}% changed in 1.08
757 \def\XINT_jrr_loop_a #1#2%
758 {%
759   \expandafter\XINT_jrr_loop_b
760   \romannumeral0\XINT_div_prepare {#1}{#2}{#1}%
761 }%
762 \def\XINT_jrr_loop_b #1#2#3#4#5#6#7%
763 {%
764   \expandafter \XINT_jrr_loop_c \expandafter
765   {\romannumeral0\xintiiadd{\XINT_Mul{#4}{#1}}{#6}}%
766   {\romannumeral0\xintiiadd{\XINT_Mul{#5}{#1}}{#7}}%
767   {#2}{#3}{#4}{#5}%
768 }%
769 \def\XINT_jrr_loop_c #1#2%
770 {%
771   \expandafter \XINT_jrr_loop_d \expandafter{#2}{#1}%
772 }%
773 \def\XINT_jrr_loop_d #1#2#3#4%
774 {%
775   \XINT_jrr_loop_e #3\Z {#4}{#2}{#1}%
776 }%
777 \def\XINT_jrr_loop_e #1#2\Z
778 {%
779   \xint_gob_til_zero #1\xint_jrr_loop_exit0\XINT_jrr_loop_a {#1#2}%
780 }%
781 \def\xint_jrr_loop_exit0\XINT_jrr_loop_a #1#2#3#4#5#6%
782 {%
783   \XINT_irr_finish {#3}{#4}%
784 }%

```

### 39.28 \xintTFrac

1.09i, for frac in \xintexpr. And \xintFrac is already assigned. T for truncation. However, potentially not very efficient with numbers in scientific notations, with big exponents. Will have to think it again some day. I hesitated how to call the macro. Same convention as in maple, but some people reserve fractional part to  $x - \text{floor}(x)$ . Also, not clear if I had to make it negative (or zero) if  $x < 0$ , or rather always positive. There should be in fact such a thing for each rounding function, trunc, round, floor, ceil.

```

785 \def\xintTFrac {\romannumeral0\xinttfrac }%
786 \def\xinttfrac #1%
787   {\expandafter\XINT_tfrac_fork\romannumeral0\xintrawwithzeros {#1}\Z }%
788 \def\XINT_tfrac_fork #1%
789 {%
790   \xint_UDzerominusfork

```

```

791      #1-\XINT_tfrac_zero
792      0#1\XINT_tfrac_N
793      0-\XINT_tfrac_P #1}%
794      \krof
795 }%
796 \def\XINT_tfrac_zero #1\Z { 0/1[0]}%
797 \def\XINT_tfrac_N {\expandafter\XINT_opp\romannumeral0\XINT_tfrac_P }%
798 \def\XINT_tfrac_P #1/#2\Z
799 {%
800      \expandafter\XINT_rez_AB\romannumeral0\xintiirem{#1}{#2}\Z {0}{#2}%
801 }%

```

### 39.29 \XINTinFloatFrac

1.09i, for frac in \xintfloatexpr. This version computes exactly from the input the fractional part and then only converts it into a float with the asked-for number of digits. I will have to think it again some day, certainly.

```

802 \def\XINTinFloatFrac {\romannumeral0\XINTinfloatfrac }%
803 \def\XINTinfloatfrac [#1]#2%
804 {%
805      \expandafter\XINT_infloatfrac_a\expandafter
806      {\romannumeral0\xinttfrac{#2}}{#1}%
807 }%
808 \def\XINT_infloatfrac_a #1#2{\XINTinFloat [#2]{#1}}%

```

### 39.30 \xintTrunc, \xintiTrunc

Modified in 1.06 to give the first argument to a \numexpr.

1.09f fixes the overhead added in 1.09a to some inner routines when \xintiquo was redefined to use \xintnum. Now uses \xintiiquo, rather.

1.09j: minor improvements, \XINT\_trunc\_E was very strange and defined two never occuring branches; also, optimizes the call to the division routine, and the zero loops.

```

809 \def\xintTrunc {\romannumeral0\xinttrunc }%
810 \def\xintiTrunc {\romannumeral0\xintitrunc }%
811 \def\xinttrunc #1%
812 {%
813      \expandafter\XINT_trunc\expandafter {\the\numexpr #1}%
814 }%
815 \def\XINT_trunc #1#2%
816 {%
817      \expandafter\XINT_trunc_G
818      \romannumeral0\expandafter\XINT_trunc_A
819      \romannumeral0\XINT_infrac {#2}{#1}{#1}%
820 }%
821 \def\xintitrunc #1%

```

```

822 {%
823   \expandafter\XINT_itrunc\expandafter {\the\numexpr #1}%
824 }%
825 \def\XINT_itrunc #1#2%
826 {%
827   \expandafter\XINT_itrunc_G
828   \romannumeral0\expandafter\XINT_trunc_A
829   \romannumeral0\XINT_infrac {#2}{#1}{#1}%
830 }%
831 \def\XINT_trunc_A #1#2#3#4%
832 {%
833   \expandafter\XINT_trunc_checkifzero
834   \expandafter{\the\numexpr #1+#4}#2\Z {#3}%
835 }%
836 \def\XINT_trunc_checkifzero #1#2#3\Z
837 {%
838   \xint_gob_til_zero #2\XINT_trunc_iszero0\XINT_trunc_B {#1}{#2#3}%
839 }%
840 \def\XINT_trunc_iszero0\XINT_trunc_B #1#2#3{ 0\Z 0}%
841 \def\XINT_trunc_B #1%
842 {%
843   \ifcase\XINT_cntSgn #1\Z
844     \expandafter\XINT_trunc_D
845   \or
846     \expandafter\XINT_trunc_D
847   \else
848     \expandafter\XINT_trunc_C
849   \fi
850   {#1}%
851 }%
852 \def\XINT_trunc_C #1#2#3%
853 {%
854   \expandafter\XINT_trunc_CE\expandafter
855   {\romannumeral0\XINT_dsx_zero loop {-#1}{ }\Z {#3}}{#2}%
856 }%
857 \def\XINT_trunc_CE #1#2{\XINT_trunc_E #2.{#1}}%
858 \def\XINT_trunc_D #1#2%
859 {%
860   \expandafter\XINT_trunc_E
861   \romannumeral0\XINT_dsx_zero loop {#1}{ }\Z {#2}.%
862 }%
863 \def\XINT_trunc_E #1%
864 {%
865   \xint_UDsignfork
866     #1\XINT_trunc_Fneg
867     -{\XINT_trunc_Fpos #1}%
868   \krof
869 }%
870 \def\XINT_trunc_Fneg #1.#2{\expandafter\xint_firstoftwo_thenstop

```

```

871      \romannumeral0\XINT_div_prepare {#2}{#1}\Z \xint_minus_thenstop}%
872 \def\XINT_trunc_Fpos #1.#2{\expandafter\xint_firstoftwo_thenstop
873      \romannumeral0\XINT_div_prepare {#2}{#1}\Z \space }%
874 \def\XINT_itrunc_G #1#2\Z #3#4%
875 {%
876     \xint_gob_til_zero #1\XINT_trunc_zero 0#3#1#2%
877 }%
878 \def\XINT_trunc_zero 0#1#20{ 0}%
879 \def\XINT_trunc_G #1\Z #2#3%
880 {%
881     \xint_gob_til_zero #2\XINT_trunc_zero 0%
882     \expandafter\XINT_trunc_H\expandafter
883     {\the\numexpr\romannumeral0\xintlength {#1}-#3}{#3}{#1}#2%
884 }%
885 \def\XINT_trunc_H #1#2%
886 {%
887     \ifnum #1 > \xint_c_
888         \xint_afterfi {\XINT_trunc_Ha {#2}}%
889     \else
890         \xint_afterfi {\XINT_trunc_Hb {-#1}}% -0,--1,--2, ....
891     \fi
892 }%
893 \def\XINT_trunc_Ha
894 {%
895     \expandafter\XINT_trunc_Haa\romannumeral0\xintdecsplit
896 }%
897 \def\XINT_trunc_Haa #1#2#3%
898 {%
899     #3#1.#2%
900 }%
901 \def\XINT_trunc_Hb #1#2#3%
902 {%
903     \expandafter #3\expandafter0\expandafter.%
904     \romannumeral0\XINT_dsx_zero loop {#1}{\Z }{#2} #1=-0 autorisé !
905 }%

```

### 39.31 \xintRound, \xintiRound

Modified in 1.06 to give the first argument to a \numexpr.

```

906 \def\xintRound {\romannumeral0\xintround }%
907 \def\xintiRound {\romannumeral0\xintiround }%
908 \def\xintround #1%
909 {%
910     \expandafter\XINT_round\expandafter {\the\numexpr #1}%
911 }%
912 \def\XINT_round
913 {%
914     \expandafter\XINT_trunc_G\romannumeral0\XINT_round_A

```

```

915 }%
916 \def\xintiround #1%
917 {%
918   \expandafter\XINT_iround\expandafter {\the\numexpr #1}%
919 }%
920 \def\XINT_iround
921 {%
922   \expandafter\XINT_itrunc_G\romannumeral0\XINT_round_A
923 }%
924 \def\XINT_round_A #1#2%
925 {%
926   \expandafter\XINT_round_B
927   \romannumeral0\expandafter\XINT_trunc_A
928   \romannumeral0\XINT_infrac {#2}{\the\numexpr #1+1\relax}{#1}%
929 }%
930 \def\XINT_round_B #1\Z
931 {%
932   \expandafter\XINT_round_C
933   \romannumeral0\XINT_rord_main {}#1%
934   \xint_relax
935   \xint_bye\xint_bye\xint_bye\xint_bye
936   \xint_bye\xint_bye\xint_bye\xint_bye
937   \xint_relax
938   \Z
939 }%
940 \def\XINT_round_C #1%
941 {%
942   \ifnum #1<5
943     \expandafter\XINT_round_Daa
944   \else
945     \expandafter\XINT_round_Dba
946   \fi
947 }%
948 \def\XINT_round_Daa #1%
949 {%
950   \xint_gob_til_Z #1\XINT_round_Daz\Z \XINT_round_Da #1%
951 }%
952 \def\XINT_round_Daz\Z \XINT_round_Da \Z { 0\Z }%
953 \def\XINT_round_Da #1\Z
954 {%
955   \XINT_rord_main {}#1%
956   \xint_relax
957   \xint_bye\xint_bye\xint_bye\xint_bye
958   \xint_bye\xint_bye\xint_bye\xint_bye
959   \xint_relax \Z
960 }%
961 \def\XINT_round_Dba #1%
962 {%
963   \xint_gob_til_Z #1\XINT_round_Dbz\Z \XINT_round_Db #1%

```

```

964 }%
965 \def\XINT_round_Db\Z \XINT_round_Db \Z { 1\Z }%
966 \def\XINT_round_Db #1\Z
967 {%
968   \XINT_addm_A 0{}1000\W\X\Y\Z #1000\W\X\Y\Z \Z
969 }%

```

### 39.32 \xintXTrunc

1.09j [2014/01/06] This is completely expandable but not f-expandable. Designed to be used inside an `\edef` or a `\write`, if one is interested in getting tens of thousands of digits from the decimal expansion of some fraction... it is not worth using it rather than `\xintTrunc` if for less than \*hundreds\* of digits. For efficiency it clones part of the preparatory division macros, as the same denominator will be used again and again. The `D` parameter which says how many digits to keep after decimal mark must be at least 1 (and it is forcefully set to such a value if found negative or zero, to avoid an eternal loop).

For reasons of efficiency I try to use the shortest possible denominator, so if the fraction is  $A/B[N]$ , I want to use  $B$ . For  $N$  at least zero, just immediately replace  $A$  by  $A \cdot 10^N$ . The first division then may be a little longish but the next ones will be fast (if  $B$  is not too big). For  $N < 0$ , this is a bit more complicated. I thought somewhat about this, and I would need a rather complicated approach going through a long division algorithm, forcing me to essentially clone the actual division with some differences; a side thing is that as this would use blocks of four digits I would have a hard time allowing a non-multiple of four number of post decimal mark digits.

Thus, for  $N < 0$ , another method is followed. First the euclidean division  $A/B = Q + R/B$  is done. The number of digits of  $Q$  is  $M$ . If

$N \leq D$ , we launch `%` inside a `\csname` the routine for obtaining  $D-N$  next digits (this may impact `%` TeX's memory if  $D$  is very big), call them  $T$ . We then need to position the `%` decimal mark  $D$  slots from the right of  $QT$ , which has length  $M+D-N$ , hence  $N$  `%` slots from the right of  $Q$ . We thus avoid having to work with the  $T$ , as  $D$  may `%` be very very big (`\xintXTrunc`'s only goal is to make it possible to learn by `%` hearts decimal expansions with thousands of digits). We can use the `% \xintDecSplit` for that on  $Q$ . Computing the length  $M$  of  $Q$  was a more or less `%` unavoidable step. If  $N > D$ , the `\csname` step is skipped we need to remove the  $D-N$  last digits from  $Q$ , etc.. we compare  $D-N$  with the length  $M$  of  $Q$  etc... `%` (well in this last, very uncommon, branch, I stopped trying to optimize things `%` and I even do an `\xintnum` to ensure a 0 if something comes out empty from `% \xintDecSplit`).

```

970 \def\xintXTrunc #1#2%
971 {%
972   \expandafter\XINT_xtrunc_a\expandafter
973   {\the\numexpr #1\expandafter}\romannumeral0\xintraw {#2}%
974 }%
975 \def\XINT_xtrunc_a #1%
976 {%
977   \expandafter\XINT_xtrunc_b\expandafter

```

[illegible]

```

1027 \def\XINT_xtrunc_negN_R #1#2#3#4#5%
1028 {%
1029   \expandafter\XINT_xtrunc_negN_S\expandafter
1030   {\the\numexpr -#4}{#5}{#2}{#3}{#1}%
1031 }%
1032 \def\XINT_xtrunc_negN_S #1#2%
1033 {%
1034   \expandafter\XINT_xtrunc_negN_T\expandafter
1035   {\the\numexpr #2-#1}{#1}{#2}%
1036 }%
1037 \def\XINT_xtrunc_negN_T #1%
1038 {%
1039   \ifnum \xint_c_<#1
1040     \expandafter\XINT_xtrunc_negNA
1041   \else
1042     \expandafter\XINT_xtrunc_negNW
1043   \fi {#1}%
1044 }%
1045 % #1=D-|N|>0, #2=|N|, #3=D, #4=R, #5=B, #6=Q
1046 \def\XINT_xtrunc_unlock #10.{ }%
1047 \def\XINT_xtrunc_negNA #1#2#3#4#5#6%
1048 {%
1049   \expandafter\XINT_xtrunc_negNB\expandafter
1050   {\romannumeral0\expandafter\expandafter\expandafter
1051    \XINT_xtrunc_unlock\expandafter\string
1052    \csname\XINT_xtrunc_b {#1}#4/#5[0]\expandafter\endcsname
1053    \expandafter}\expandafter
1054    {\the\numexpr\xintLength{#6}-#2}{#6}%
1055 }%
1056 \def\XINT_xtrunc_negNB #1#2#3{\XINT_xtrunc_negNC {#2}{#3}#1}%
1057 \def\XINT_xtrunc_negNC #1%
1058 {%
1059   \ifnum \xint_c_ < #1
1060     \expandafter\XINT_xtrunc_negNDa
1061   \else
1062     \expandafter\XINT_xtrunc_negNE
1063   \fi {#1}%
1064 }%
1065 \def\XINT_xtrunc_negNDa #1#2%
1066 {%
1067   \expandafter\XINT_xtrunc_negNDb%
1068   \romannumeral0\XINT_split_fromleft_loop {#1}{#2\W\W\W\W\W\W\W\W\Z
1069 }%
1070 \def\XINT_xtrunc_negNDb #1#2{#1.#2}%
1071 \def\XINT_xtrunc_negNE #1#2%
1072 {%
1073   0.\romannumeral0\XINT_dsx_zeroloop {-#1}{}\Z {}#2%
1074 }%
1075 % #1=D-|N|<=0, #2=|N|, #3=D, #4=R, #5=B, #6=Q

```

[illegible]

[illegible]

[illegible]

### 39.33 \xintDigits

The mathchardef used to be called `\XINT_digits`, but for reasons originating in `\xintNewExpr`, release 1.09a uses `\XINTdigits` without underscore.

```

1214 \mathchardef\XINTdigits 16
1215 \def\xintDigits #1#2%
1216     {\afterassignment \xint_gobble_i \mathchardef\XINTdigits=%}

```

```
1217 \def\xinttheDigits {\number\XINTdigits }%
```

### 39.34 \xintFloat

1.07. Completely re-written in 1.08a, with spectacular speed gains. The earlier version was seriously silly when dealing with inputs having a big power of ten. Again some modifications in 1.08b for a better treatment of cases with long explicit numerators or denominators.

Here again some inner macros used the \xintquo with extra \xintnum overhead in 1.09a, 1.09f reinstalled use of \xintiigo without this overhead.

```
1218 \def\xintFloat {\romannumeral0\xintfloat }%
1219 \def\xintfloat #1{\XINT_float_chkopt #1\Z }%
1220 \def\XINT_float_chkopt #1%
1221 {%
1222   \ifx [#1\expandafter\XINT_float_opt
1223     \else\expandafter\XINT_float_noopt
1224   \fi #1%
1225 }%
1226 \def\XINT_float_noopt #1\Z
1227 {%
1228   \expandafter\XINT_float_a\expandafter\XINTdigits
1229   \romannumeral0\XINT_infrac {#1}\XINT_float_Q
1230 }%
1231 \def\XINT_float_opt [\Z #1]#2%
1232 {%
1233   \expandafter\XINT_float_a\expandafter
1234   {\the\numexpr #1\expandafter}%
1235   \romannumeral0\XINT_infrac {#2}\XINT_float_Q
1236 }%
1237 \def\XINT_float_a #1#2#3% #1=P, #2=n, #3=A, #4=B
1238 {%
1239   \XINT_float_fork #3\Z {#1}{#2}% #1 = precision, #2=n
1240 }%
1241 \def\XINT_float_fork #1%
1242 {%
1243   \xint_UDzerominusfork
1244   #1-\XINT_float_zero
1245   0#1\XINT_float_J
1246   0-{\XINT_float_K #1}%
1247   \krof
1248 }%
1249 \def\XINT_float_zero #1\Z #2#3#4#5{ 0.e0}%
1250 \def\XINT_float_J {\expandafter\xint_minus_thenstop\romannumeral0\XINT_float_K }%
1251 \def\XINT_float_K #1\Z #2% #1=A, #2=P, #3=n, #4=B
1252 {%
1253   \expandafter\XINT_float_L\expandafter
1254   {\the\numexpr\xintLength{#1}\expandafter}\expandafter
1255   {\the\numexpr #2+\xint_c_ii}{#1}{#2}%

```

```

1256 }%
1257 \def\XINT_float_L #1#2%
1258 {%
1259   \ifnum #1>#2
1260     \expandafter\XINT_float_Ma
1261   \else
1262     \expandafter\XINT_float_Mc
1263   \fi {#1}{#2}%
1264 }%
1265 \def\XINT_float_Ma #1#2#3%
1266 {%
1267   \expandafter\XINT_float_Mb\expandafter
1268   {\the\numexpr #1-#2\expandafter\expandafter\expandafter}%
1269   \expandafter\expandafter\expandafter
1270   {\expandafter\xint_firstoftwo
1271     \romannumeral0\XINT_split_fromleft_loop {#2}{#3}\W\W\W\W\W\W\W\W\Z
1272     }{#2}%
1273 }%
1274 \def\XINT_float_Mb #1#2#3#4#5#6% #2=A', #3=P+2, #4=P, #5=n, #6=B
1275 {%
1276   \expandafter\XINT_float_N\expandafter
1277   {\the\numexpr\xintLength{#6}\expandafter}\expandafter
1278   {\the\numexpr #3\expandafter}\expandafter
1279   {\the\numexpr #1+#5}%
1280   {#6}{#3}{#2}{#4}%
1281 }% long de B, P+2, n', B, |A'|=P+2, A', P
1282 \def\XINT_float_Mc #1#2#3#4#5#6%
1283 {%
1284   \expandafter\XINT_float_N\expandafter
1285   {\romannumeral0\xintlength{#6}}{#2}{#5}{#6}{#1}{#3}{#4}%
1286 }% long de B, P+2, n, B, |A|, A, P
1287 \def\XINT_float_N #1#2%
1288 {%
1289   \ifnum #1>#2
1290     \expandafter\XINT_float_O
1291   \else
1292     \expandafter\XINT_float_P
1293   \fi {#1}{#2}%
1294 }%
1295 \def\XINT_float_O #1#2#3#4%
1296 {%
1297   \expandafter\XINT_float_P\expandafter
1298   {\the\numexpr #2\expandafter}\expandafter
1299   {\the\numexpr #2\expandafter}\expandafter
1300   {\the\numexpr #3-#1+#2\expandafter\expandafter\expandafter}%
1301   \expandafter\expandafter\expandafter
1302   {\expandafter\xint_firstoftwo
1303     \romannumeral0\XINT_split_fromleft_loop {#2}{#4}\W\W\W\W\W\W\W\W\Z
1304     }%

```

```

1305 }% |B|,P+2,n,B,|A|,A,P
1306 \def\XINT_float_P #1#2#3#4#5#6#7#8%
1307 {%
1308   \expandafter #8\expandafter {\the\numexpr #1-#5+#2-\xint_c_i}%
1309   {#6}{#4}{#7}{#3}%
1310 }% |B|-|A|+P+1,A,B,P,n
1311 \def\XINT_float_Q #1%
1312 {%
1313   \ifnum #1<\xint_c_
1314     \expandafter\XINT_float_Ri
1315   \else
1316     \expandafter\XINT_float_Rii
1317   \fi {#1}%
1318 }%
1319 \def\XINT_float_Ri #1#2#3%
1320 {%
1321   \expandafter\XINT_float_Sa
1322   \romannumeral0\xintiique {#2}%
1323   {\XINT_dsx_addzerosnofuss {-#1}{#3}}\Z {#1}%
1324 }%
1325 \def\XINT_float_Rii #1#2#3%
1326 {%
1327   \expandafter\XINT_float_Sa
1328   \romannumeral0\xintiique
1329   {\XINT_dsx_addzerosnofuss {#1}{#2}}{#3}\Z {#1}%
1330 }%
1331 \def\XINT_float_Sa #1%
1332 {%
1333   \if #19%
1334     \xint_afterfi {\XINT_float_Sb\XINT_float_Wb }%
1335   \else
1336     \xint_afterfi {\XINT_float_Sb\XINT_float_Wa }%
1337   \fi #1%
1338 }%
1339 \def\XINT_float_Sb #1#2\Z #3#4%
1340 {%
1341   \expandafter\XINT_float_T\expandafter
1342   {\the\numexpr #4+\xint_c_i\expandafter}%
1343   \romannumeral-'0\XINT_lenrord_loop 0{}#2\Z\W\W\W\W\W\W\W\W\Z #1{#3}{#4}%
1344 }%
1345 \def\XINT_float_T #1#2#3%
1346 {%
1347   \ifnum #2>#1
1348     \xint_afterfi{\XINT_float_U\XINT_float_Xb}%
1349   \else
1350     \xint_afterfi{\XINT_float_U\XINT_float_Xa #3}%
1351   \fi
1352 }%
1353 \def\XINT_float_U #1#2%

```

```

1354 {%
1355   \ifnum #2<\xint_c_v
1356     \expandafter\XINT_float_Va
1357   \else
1358     \expandafter\XINT_float_Vb
1359   \fi #1%
1360}%
1361\def\XINT_float_Va #1#2\Z #3%
1362{%
1363   \expandafter#1%
1364   \romannumeral0\expandafter\XINT_float_Wa
1365   \romannumeral0\XINT_rord_main { }#2%
1366   \xint_relax
1367   \xint_bye\xint_bye\xint_bye\xint_bye
1368   \xint_bye\xint_bye\xint_bye\xint_bye
1369   \xint_relax \Z
1370}%
1371\def\XINT_float_Vb #1#2\Z #3%
1372{%
1373   \expandafter #1%
1374   \romannumeral0\expandafter #3%
1375   \romannumeral0\XINT_addm_A 0{ }1000\W\X\Y\Z #2000\W\X\Y\Z \Z
1376}%
1377\def\XINT_float_Wa #1{ #1.}%
1378\def\XINT_float_Wb #1#2%
1379   {\if #11\xint_afterfi{ 10.}\else\xint_afterfi{ #1.#2}\fi}%
1380\def\XINT_float_Xa #1\Z #2#3#4%
1381{%
1382   \expandafter\XINT_float_Y\expandafter
1383   {\the\numexpr #3+#4-#2}{#1}%
1384}%
1385\def\XINT_float_Xb #1\Z #2#3#4%
1386{%
1387   \expandafter\XINT_float_Y\expandafter
1388   {\the\numexpr #3+#4+\xint_c_i-#2}{#1}%
1389}%
1390\def\XINT_float_Y #1#2{ #2e#1}%

```

### 39.35 \XINTinFloat

1.07. Completely rewritten in 1.08a for immensely greater efficiency when the power of ten is big: previous version had some very serious bottlenecks arising from the creation of long strings of zeros, which made things such as  $2^{9999999}$  completely impossible, but now even  $2^{999999999}$  with 24 significant digits is no problem! Again (slightly) improved in 1.08b.

I decide in 1.09a not to use anymore `\romannumeral'-0` mais `\romannumeral0` also in the float routines, for consistency of style.

Here again some inner macros used the `\xintquo` with extra `\xintnum` overhead in 1.09a, 1.09f fixed that to use `\xintiiquo` for example.

1.09i added a stupid bug to `\XINT_infloat_zero` when it changed `0[0]` to a silly `0/1[0]`, breaking in particular `\xintFloatAdd` when one of the argument is zero :(((

1.09j fixes this. Besides, for notational coherence `\XINT_inFloat` and `\XINT_infloat` have been renamed respectively `\XINTinFloat` and `\XINT_infloat` in release 1.09j.

```

1391 \def\XINTinFloat {\romannumeral0\XINTinfloat }%
1392 \def\XINTinfloat [#1]#2%
1393 {%
1394   \expandafter\XINT_infloat_a\expandafter
1395   {\the\numexpr #1\expandafter}%
1396   \romannumeral0\XINT_infrac {#2}\XINT_infloat_Q
1397 }%
1398 \def\XINT_infloat_a #1#2#3% #1=P, #2=n, #3=A, #4=B
1399 {%
1400   \XINT_infloat_fork #3\Z {#1}{#2}% #1 = precision, #2=n
1401 }%
1402 \def\XINT_infloat_fork #1%
1403 {%
1404   \xint_UDzerominusfork
1405   #1-\XINT_infloat_zero
1406   0#1\XINT_infloat_J
1407   0-{\XINT_float_K #1}%
1408   \krof
1409 }%
1410 \def\XINT_infloat_zero #1\Z #2#3#4#5{ 0[0]}%
1411 % the 0[0] was stupidly changed to 0/1[0] in 1.09i, with the result that the
1412 % Float addition would crash when an operand was zero
1413 \def\XINT_infloat_J {\expandafter-\romannumeral0\XINT_float_K }%
1414 \def\XINT_infloat_Q #1%
1415 {%
1416   \ifnum #1<\xint_c_
1417     \expandafter\XINT_infloat_Ri
1418   \else
1419     \expandafter\XINT_infloat_Rii
1420   \fi {#1}%
1421 }%
1422 \def\XINT_infloat_Ri #1#2#3%
1423 {%
1424   \expandafter\XINT_infloat_S\expandafter
1425   {\romannumeral0\xintiiquo {#2}%
1426    {\XINT_dsx_addzerosnofuss {-#1}{#3}}{#1}%
1427 }%
1428 \def\XINT_infloat_Rii #1#2#3%
1429 {%
1430   \expandafter\XINT_infloat_S\expandafter
1431   {\romannumeral0\xintiiquo
1432    {\XINT_dsx_addzerosnofuss {#1}{#2}}{#3}}{#1}%
1433 }%

```

```

1434 \def\XINT_infloat_S #1#2#3%
1435 {%
1436   \expandafter\XINT_infloat_T\expandafter
1437   {\the\numexpr #3+\xint_c_i\expandafter}%
1438   \romannumeral-'0\XINT_lenrord_loop 0{ }#1\Z\W\W\W\W\W\W\W\Z
1439   {#2}%
1440 }%
1441 \def\XINT_infloat_T #1#2#3%
1442 {%
1443   \ifnum #2>#1
1444     \xint_afterfi{\XINT_infloat_U\XINT_infloat_Wb}%
1445   \else
1446     \xint_afterfi{\XINT_infloat_U\XINT_infloat_Wa #3}%
1447   \fi
1448 }%
1449 \def\XINT_infloat_U #1#2%
1450 {%
1451   \ifnum #2<\xint_c_v
1452     \expandafter\XINT_infloat_Va
1453   \else
1454     \expandafter\XINT_infloat_Vb
1455   \fi #1%
1456 }%
1457 \def\XINT_infloat_Va #1#2\Z
1458 {%
1459   \expandafter#1%
1460   \romannumeral0\XINT_rord_main { }#2%
1461   \xint_relax
1462   \xint_bye\xint_bye\xint_bye\xint_bye
1463   \xint_bye\xint_bye\xint_bye\xint_bye
1464   \xint_relax \Z
1465 }%
1466 \def\XINT_infloat_Vb #1#2\Z
1467 {%
1468   \expandafter #1%
1469   \romannumeral0\XINT_addm_A 0{ }1000\W\X\Y\Z #2000\W\X\Y\Z \Z
1470 }%
1471 \def\XINT_infloat_Wa #1\Z #2#3%
1472 {%
1473   \expandafter\XINT_infloat_X\expandafter
1474   {\the\numexpr #3+\xint_c_i-#2}{#1}%
1475 }%
1476 \def\XINT_infloat_Wb #1\Z #2#3%
1477 {%
1478   \expandafter\XINT_infloat_X\expandafter
1479   {\the\numexpr #3+\xint_c_ii-#2}{#1}%
1480 }%
1481 \def\XINT_infloat_X #1#2{ #2[#1]}%

```

**39.36 \xintAdd**

```

1482 \def\xintAdd {\romannumeral0\xintadd }%
1483 \def\xintadd #1%
1484 {%
1485   \expandafter\xint_fadd\expandafter {\romannumeral0\XINT_infrac {#1}}%
1486 }%
1487 \def\xint_fadd #1#2{\expandafter\XINT_fadd_A\romannumeral0\XINT_infrac{#2}#1}%
1488 \def\XINT_fadd_A #1#2#3#4%
1489 {%
1490   \ifnum #4 > #1
1491     \xint_afterfi {\XINT_fadd_B {#1}}%
1492   \else
1493     \xint_afterfi {\XINT_fadd_B {#4}}%
1494   \fi
1495   {#1}{#4}{#2}{#3}%
1496 }%
1497 \def\XINT_fadd_B #1#2#3#4#5#6#7%
1498 {%
1499   \expandafter\XINT_fadd_C\expandafter
1500   {\romannumeral0\xintiimul {#7}{#5}}%
1501   {\romannumeral0\xintiimul
1502   {\romannumeral0\xintiimul {\xintDSH {\the\numexpr -#3+#1\relax}{#6}}{#5}}%
1503   {\romannumeral0\xintiimul {#7}{\xintDSH {\the\numexpr -#2+#1\relax}{#4}}}%
1504   }%
1505   {#1}%
1506 }%
1507 \def\XINT_fadd_C #1#2#3%
1508 {%
1509   \expandafter\XINT_fadd_D\expandafter {#2}{#3}{#1}%
1510 }%
1511 \def\XINT_fadd_D #1#2{\XINT_outfrac {#2}{#1}}%

```

**39.37 \xintSub**

```

1512 \def\xintSub {\romannumeral0\xintsub }%
1513 \def\xintsub #1%
1514 {%
1515   \expandafter\xint_fsub\expandafter {\romannumeral0\XINT_infrac {#1}}%
1516 }%
1517 \def\xint_fsub #1#2%
1518   {\expandafter\XINT_fsub_A\romannumeral0\XINT_infrac {#2}#1}%
1519 \def\XINT_fsub_A #1#2#3#4%
1520 {%
1521   \ifnum #4 > #1
1522     \xint_afterfi {\XINT_fsub_B {#1}}%
1523   \else
1524     \xint_afterfi {\XINT_fsub_B {#4}}%
1525   \fi
1526   {#1}{#4}{#2}{#3}%

```

```

1527 }%
1528 \def\XINT_fsub_B #1#2#3#4#5#6#7%
1529 {%
1530   \expandafter\XINT_fsub_C\expandafter
1531   {\romannumeral0\xintiimul {#7}{#5}}%
1532   {\romannumeral0\xintiisub
1533   {\romannumeral0\xintiimul {\xintDSH {\the\numexpr -#3+#1\relax}{#6}}{#5}}%
1534   {\romannumeral0\xintiimul {#7}{\xintDSH {\the\numexpr -#2+#1\relax}{#4}}}%
1535   }%
1536   {#1}%
1537 }%
1538 \def\XINT_fsub_C #1#2#3%
1539 {%
1540   \expandafter\XINT_fsub_D\expandafter {#2}{#3}{#1}%
1541 }%
1542 \def\XINT_fsub_D #1#2{\XINT_outfrac {#2}{#1}}%

```

### 39.38 \xintSum

```

1543 \def\xintSum {\romannumeral0\xintsum }%
1544 \def\xintsum #1{\xintsumexpr #1\relax }%
1545 \def\xintSumExpr {\romannumeral0\xintsumexpr }%
1546 \def\xintsumexpr {\expandafter\XINT_fsumexpr\romannumeral-‘0}%
1547 \def\XINT_fsumexpr {\XINT_fsum_loop_a {0/1[0]}}%
1548 \def\XINT_fsum_loop_a #1#2%
1549 {%
1550   \expandafter\XINT_fsum_loop_b \romannumeral-‘0#2\Z {#1}%
1551 }%
1552 \def\XINT_fsum_loop_b #1%
1553 {%
1554   \xint_gob_til_relax #1\XINT_fsum_finished\relax
1555   \XINT_fsum_loop_c #1%
1556 }%
1557 \def\XINT_fsum_loop_c #1\Z #2%
1558 {%
1559   \expandafter\XINT_fsum_loop_a\expandafter{\romannumeral0\xintadd {#2}{#1}}%
1560 }%
1561 \def\XINT_fsum_finished #1\Z #2{ #2}%

```

### 39.39 \xintMul

```

1562 \def\xintMul {\romannumeral0\xintmul }%
1563 \def\xintmul #1%
1564 {%
1565   \expandafter\xint_fmulo\expandafter {\romannumeral0\XINT_infrac {#1}}%
1566 }%
1567 \def\xint_fmulo #1#2%
1568   {\expandafter\XINT_fmulo_A\romannumeral0\XINT_infrac {#2}{#1}}%
1569 \def\XINT_fmulo_A #1#2#3#4#5#6%
1570 {%
1571   \expandafter\XINT_fmulo_B

```

```

1572 \expandafter{\the\numexpr #1+#4\expandafter}%
1573 \expandafter{\romannumeral0\xintiimul {#6}{#3}}%
1574 {\romannumeral0\xintiimul {#5}{#2}}%
1575 }%
1576 \def\XINT_fmulo_B #1#2#3%
1577 {%
1578 \expandafter \XINT_fmulo_C \expandafter{#3}{#1}{#2}%
1579 }%
1580 \def\XINT_fmulo_C #1#2{\XINT_outfrac {#2}{#1}}%

```

### 39.40 \xintSqr

```

1581 \def\xintSqr {\romannumeral0\xintsqr }%
1582 \def\xintsqr #1%
1583 {%
1584 \expandafter\xint_fsqr\expandafter{\romannumeral0\XINT_infrac {#1}}%
1585 }%
1586 \def\xint_fsqr #1{\XINT_fmulo_A #1#1}%

```

### 39.41 \xintPow

Modified in 1.06 to give the exponent to a \numexpr.

With 1.07 and for use within the \xintexpr parser, we must allow fractions (which are integers in disguise) as input to the exponent, so we must have a variant which uses \xintNum and not only \numexpr for normalizing the input. Hence the \xintfPow here.

1.08b: well actually I think that with xintfrac.sty loaded the exponent should always be allowed to be a fraction giving an integer. So I do as for \xintFac, and remove here the duplicated. Then \xintexpr can use the \xintPow as defined here.

```

1587 \def\xintPow {\romannumeral0\xintpow }%
1588 \def\xintpow #1%
1589 {%
1590 \expandafter\xint_fpow\expandafter {\romannumeral0\XINT_infrac {#1}}%
1591 }%
1592 \def\xint_fpow #1#2%
1593 {%
1594 \expandafter\XINT_fpow_fork\the\numexpr \xintNum{#2}\relax\Z #1%
1595 }%
1596 \def\XINT_fpow_fork #1#2\Z
1597 {%
1598 \xint_UDzerominusfork
1599 #1-\XINT_fpow_zero
1600 0#1\XINT_fpow_neg
1601 0-{\XINT_fpow_pos #1}%
1602 \krof
1603 {#2}%
1604 }%
1605 \def\XINT_fpow_zero #1#2#3#4{ 1/1[0]}%
1606 \def\XINT_fpow_pos #1#2#3#4#5%

```

```

1607 {%
1608   \expandafter\XINT_fpow_pos_A\expandafter
1609   {\the\numexpr #1#2*#3\expandafter}\expandafter
1610   {\romannumeral0\xintiipow {#5}{#1#2}}%
1611   {\romannumeral0\xintiipow {#4}{#1#2}}%
1612 }%
1613 \def\XINT_fpow_neg #1#2#3#4%
1614 {%
1615   \expandafter\XINT_fpow_pos_A\expandafter
1616   {\the\numexpr -#1*#2\expandafter}\expandafter
1617   {\romannumeral0\xintiipow {#3}{#1}}%
1618   {\romannumeral0\xintiipow {#4}{#1}}%
1619 }%
1620 \def\XINT_fpow_pos_A #1#2#3%
1621 {%
1622   \expandafter\XINT_fpow_pos_B\expandafter {#3}{#1}{#2}%
1623 }%
1624 \def\XINT_fpow_pos_B #1#2{\XINT_outfrac {#2}{#1}}%

```

### 39.42 \xintFac

1.07: to be used by the \xintexpr scanner which needs to be able to apply \xintFac to a fraction which is an integer in disguise; so we use \xintNum and not only \numexpr. Je modifie cela dans 1.08b, au lieu d'avoir un \xintfFac spécialement pour \xintexpr, tout simplement j'étends \xintFac comme les autres macros, pour qu'elle utilise \xintNum.

```

1625 \def\xintFac {\romannumeral0\xintfac }%
1626 \def\xintfac #1%
1627 {%
1628   \expandafter\XINT_fac_fork\expandafter{\the\numexpr \xintNum{#1}}%
1629 }%

```

### 39.43 \xintPrd

```

1630 \def\xintPrd {\romannumeral0\xintprd }%
1631 \def\xintprd #1{\xintprdexpr #1\relax }%
1632 \def\xintPrdExpr {\romannumeral0\xintprdexpr }%
1633 \def\xintprdexpr {\expandafter\XINT_fprdexpr \romannumeral-'0}%
1634 \def\XINT_fprdexpr {\XINT_fprod_loop_a {1/1[0]}}%
1635 \def\XINT_fprod_loop_a #1#2%
1636 {%
1637   \expandafter\XINT_fprod_loop_b \romannumeral-'0#2\Z {#1}%
1638 }%
1639 \def\XINT_fprod_loop_b #1%
1640 {%
1641   \xint_gob_til_relax #1\XINT_fprod_finished\relax
1642   \XINT_fprod_loop_c #1%
1643 }%

```

### 39 Package *xintfrac* implementation

```

1644 \def\XINT_fprod_loop_c #1\Z #2%
1645 {%
1646   \expandafter\XINT_fprod_loop_a\expandafter{\romannumeral0\xintmul {#1}{#2}}%
1647 }%
1648 \def\XINT_fprod_finished #1\Z #2{ #2}%

```

#### 39.44 \xintDiv

```

1649 \def\xintDiv {\romannumeral0\xintdiv }%
1650 \def\xintdiv #1%
1651 {%
1652   \expandafter\xint_fdiv\expandafter {\romannumeral0\XINT_infrac {#1}}%
1653 }%
1654 \def\xint_fdiv #1#2%
1655   {\expandafter\XINT_fdiv_A\romannumeral0\XINT_infrac {#2}{#1}}%
1656 \def\XINT_fdiv_A #1#2#3#4#5#6%
1657 {%
1658   \expandafter\XINT_fdiv_B
1659   \expandafter{\the\numexpr #4-#1\expandafter}%
1660   \expandafter{\romannumeral0\xintiimul {#2}{#6}}%
1661   {\romannumeral0\xintiimul {#3}{#5}}%
1662 }%
1663 \def\XINT_fdiv_B #1#2#3%
1664 {%
1665   \expandafter\XINT_fdiv_C
1666   \expandafter{#3}{#1}{#2}%
1667 }%
1668 \def\XINT_fdiv_C #1#2{\XINT_outfrac {#2}{#1}}%

```

#### 39.45 \xintIsOne

New with 1.09a. Could be more efficient. For fractions with big powers of tens, it is better to use `\xintCmp{f}{1}`. Restyled in 1.09i.

```

1669 \def\xintIsOne {\romannumeral0\xintisone }%
1670 \def\xintisone #1{\expandafter\XINT_fracisone
1671   \romannumeral0\xintrawwithzeros{#1}\Z }%
1672 \def\XINT_fracisone #1/#2\Z
1673   {\if0\XINT_Cmp {#1}{#2}\xint_afterfi{ 1}\else\xint_afterfi{ 0}\fi}%

```

#### 39.46 \xintGeq

Rewritten completely in 1.08a to be less dumb when comparing fractions having big powers of tens.

```

1674 \def\xintGeq {\romannumeral0\xintgeq }%
1675 \def\xintgeq #1%
1676 {%
1677   \expandafter\xint_fgeq\expandafter {\romannumeral0\xintabs {#1}}%
1678 }%

```

```

1679 \def\xint_fgeq #1#2%
1680 {%
1681   \expandafter\xINT_fgeq_A \romannumeral0\xintabs {#2}#1%
1682 }%
1683 \def\xINT_fgeq_A #1%
1684 {%
1685   \xint_gob_til_zero #1\xINT_fgeq_Zii 0%
1686   \XINT_fgeq_B #1%
1687 }%
1688 \def\xINT_fgeq_Zii 0\xINT_fgeq_B #1[#2]#3[#4]{ 1}%
1689 \def\xINT_fgeq_B #1/#2[#3]#4#5/#6[#7]%
1690 {%
1691   \xint_gob_til_zero #4\xINT_fgeq_Zi 0%
1692   \expandafter\xINT_fgeq_C\expandafter
1693   {\the\numexpr #7-#3\expandafter}\expandafter
1694   {\romannumeral0\xintiimul {#4#5}{#2}}%
1695   {\romannumeral0\xintiimul {#6}{#1}}%
1696 }%
1697 \def\xINT_fgeq_Zi 0#1#2#3#4#5#6#7{ 0}%
1698 \def\xINT_fgeq_C #1#2#3%
1699 {%
1700   \expandafter\xINT_fgeq_D\expandafter
1701   {#3}{#1}{#2}%
1702 }%
1703 \def\xINT_fgeq_D #1#2#3%
1704 {%
1705   \expandafter\xINT_cntSgnFork\romannumeral-‘0\expandafter\xINT_cntSgn
1706   \the\numexpr #2+\xintLength{#3}-\xintLength{#1}\relax\Z
1707   { 0}{\XINT_fgeq_E #2\Z {#3}{#1}}{ 1}%
1708 }%
1709 \def\xINT_fgeq_E #1%
1710 {%
1711   \xint_UDsignfork
1712   #1\xINT_fgeq_Fd
1713   -{\XINT_fgeq_Fn #1}%
1714   \krof
1715 }%
1716 \def\xINT_fgeq_Fd #1\Z #2#3%
1717 {%
1718   \expandafter\xINT_fgeq_Fe\expandafter
1719   {\romannumeral0\xINT_dsx_addzerosnofuss {#1}{#3}}{#2}%
1720 }%
1721 \def\xINT_fgeq_Fe #1#2{\XINT_geq_pre {#2}{#1}}%
1722 \def\xINT_fgeq_Fn #1\Z #2#3%
1723 {%
1724   \expandafter\xINT_geq_pre\expandafter
1725   {\romannumeral0\xINT_dsx_addzerosnofuss {#1}{#2}}{#3}%
1726 }%

```

**39.47 \xintMax**

Rewritten completely in 1.08a.

```

1727 \def\xintMax {\romannumeral0\xintmax }%
1728 \def\xintmax #1%
1729 {%
1730   \expandafter\xint_fmax\expandafter {\romannumeral0\xintra{#1}}%
1731 }%
1732 \def\xint_fmax #1#2%
1733 {%
1734   \expandafter\XINT_fmax_A\romannumeral0\xintra{#2}#1%
1735 }%
1736 \def\XINT_fmax_A #1#2/#3[#4]#5#6/#7[#8]%
1737 {%
1738   \xint_UDsignsfork
1739     #1#5\XINT_fmax_minusminus
1740     -#5\XINT_fmax_firstneg
1741     #1-\XINT_fmax_secondneg
1742     --\XINT_fmax_nonneg_a
1743   \krof
1744   #1#5{#2/#3[#4]}{#6/#7[#8]}%
1745 }%
1746 \def\XINT_fmax_minusminus --%
1747   {\expandafter\xint_minus_thenstop\romannumeral0\XINT_fmin_nonneg_b }%
1748 \def\XINT_fmax_firstneg #1-#2#3{ #1#2}%
1749 \def\XINT_fmax_secondneg -#1#2#3{ #1#3}%
1750 \def\XINT_fmax_nonneg_a #1#2#3#4%
1751 {%
1752   \XINT_fmax_nonneg_b {#1#3}{#2#4}%
1753 }%
1754 \def\XINT_fmax_nonneg_b #1#2%
1755 {%
1756   \if0\romannumeral0\XINT_fgeq_A #1#2%
1757     \xint_afterfi{ #1}%
1758   \else \xint_afterfi{ #2}%
1759   \fi
1760 }%

```

**39.48 \xintMaxof**

```

1761 \def\xintMaxof {\romannumeral0\xintmaxof }%
1762 \def\xintmaxof #1{\expandafter\XINT_maxof_a\romannumeral-‘0#1\relax }%
1763 \def\XINT_maxof_a #1{\expandafter\XINT_maxof_b\romannumeral0\xintra{#1}\Z }%
1764 \def\XINT_maxof_b #1\Z #2%
1765   {\expandafter\XINT_maxof_c\romannumeral-‘0#2\Z {#1}\Z}%
1766 \def\XINT_maxof_c #1%
1767   {\xint_gob_til_relax #1\XINT_maxof_e\relax\XINT_maxof_d #1}%
1768 \def\XINT_maxof_d #1\Z

```

```

1769      {\expandafter\XINT_maxof_b\romannumeral0\xintmax {#1}}%
1770 \def\XINT_maxof_e #1\Z #2\Z { #2}%

```

### 39.49 \xintMin

Rewritten completely in 1.08a.

```

1771 \def\xintMin {\romannumeral0\xintmin }%
1772 \def\xintmin #1%
1773 {%
1774   \expandafter\xint_fmin\expandafter {\romannumeral0\xintraw {#1}}%
1775 }%
1776 \def\xint_fmin #1#2%
1777 {%
1778   \expandafter\XINT_fmin_A\romannumeral0\xintraw {#2}#1%
1779 }%
1780 \def\XINT_fmin_A #1#2/#3[#4]#5#6/#7[#8]%
1781 {%
1782   \xint_UDsignsfork
1783     #1#5\XINT_fmin_minusminus
1784     -#5\XINT_fmin_firstneg
1785     #1-\XINT_fmin_secondneg
1786     --\XINT_fmin_nonneg_a
1787   \krof
1788   #1#5{#2/#3[#4]}{#6/#7[#8]}%
1789 }%
1790 \def\XINT_fmin_minusminus --%
1791   {\expandafter\xint_minus_thenstop\romannumeral0\XINT_fmax_nonneg_b }%
1792 \def\XINT_fmin_firstneg #1-#2#3{ -#3}%
1793 \def\XINT_fmin_secondneg -#1#2#3{ -#2}%
1794 \def\XINT_fmin_nonneg_a #1#2#3#4%
1795 {%
1796   \XINT_fmin_nonneg_b {#1#3}{#2#4}%
1797 }%
1798 \def\XINT_fmin_nonneg_b #1#2%
1799 {%
1800   \if0\romannumeral0\XINT_fgeq_A #1#2%
1801     \xint_afterfi{ #2}%
1802   \else \xint_afterfi{ #1}%
1803   \fi
1804 }%

```

### 39.50 \xintMinof

```

1805 \def\xintMinof      {\romannumeral0\xintminof }%
1806 \def\xintminof      #1{\expandafter\XINT_minof_a\romannumeral-‘0#1\relax }%
1807 \def\XINT_minof_a #1{\expandafter\XINT_minof_b\romannumeral0\xintraw{#1}\Z }%
1808 \def\XINT_minof_b #1\Z #2%
1809   {\expandafter\XINT_minof_c\romannumeral-‘0#2\Z {#1}\Z}%
1810 \def\XINT_minof_c #1%

```

```

1811      {\xint_gob_til_relax #1\XINT_minof_e\relax\XINT_minof_d #1}%
1812 \def\XINT_minof_d #1\Z
1813      {\expandafter\XINT_minof_b\romannumeral0\xintmin {#1}}%
1814 \def\XINT_minof_e #1\Z #2\Z { #2}%

```

### 39.51 \xintCmp

Rewritten completely in 1.08a to be less dumb when comparing fractions having big powers of tens. Incredibly, it seems that 1.08b introduced a bug in delimited arguments making the macro just non-functional when one of the input was zero! I did not detect this until working on release 1.09a, somehow I had not tested that \xintCmp just did NOT work! I must have done some last minute change...

```

1815 \def\xintCmp {\romannumeral0\xintcmp }%
1816 \def\xintcmp #1%
1817 {%
1818     \expandafter\xint_fcmp\expandafter {\romannumeral0\xintraw {#1}}%
1819 }%
1820 \def\xint_fcmp #1#2%
1821 {%
1822     \expandafter\XINT_fcmp_A\romannumeral0\xintraw {#2}#1%
1823 }%
1824 \def\XINT_fcmp_A #1#2/#3[#4]#5#6/#7[#8]%
1825 {%
1826     \xint_UDsignsfork
1827     #1#5\XINT_fcmp_minusminus
1828     -#5\XINT_fcmp_firstneg
1829     #1-\XINT_fcmp_secondneg
1830     --\XINT_fcmp_nonneg_a
1831     \krof
1832     #1#5{#2/#3[#4]}{#6/#7[#8]}%
1833 }%
1834 \def\XINT_fcmp_minusminus --#1#2{\XINT_fcmp_B #2#1}%
1835 \def\XINT_fcmp_firstneg #1-#2#3{ -1}%
1836 \def\XINT_fcmp_secondneg -#1#2#3{ 1}%
1837 \def\XINT_fcmp_nonneg_a #1#2%
1838 {%
1839     \xint_UDzerosfork
1840     #1#2\XINT_fcmp_zerozero
1841     0#2\XINT_fcmp_firstzero
1842     #10\XINT_fcmp_secondzero
1843     00\XINT_fcmp_pos
1844     \krof
1845     #1#2%
1846 }%
1847 \def\XINT_fcmp_zerozero #1#2#3#4{ 0}% 1.08b had some [ and ] here!!!
1848 \def\XINT_fcmp_firstzero #1#2#3#4{ -1}% incredibly I never saw that until
1849 \def\XINT_fcmp_secondzero #1#2#3#4{ 1}% preparing 1.09a.
1850 \def\XINT_fcmp_pos #1#2#3#4%
1851 {%

```

```

1852 \XINT_fcmp_B #1#3#2#4%
1853 }%
1854 \def\XINT_fcmp_B #1/#2[#3]#4/#5[#6]%
1855 {%
1856 \expandafter\XINT_fcmp_C\expandafter
1857 {\the\numexpr #6-#3\expandafter}\expandafter
1858 {\romannumeral0\xintiimul {#4}{#2}}%
1859 {\romannumeral0\xintiimul {#5}{#1}}%
1860 }%
1861 \def\XINT_fcmp_C #1#2#3%
1862 {%
1863 \expandafter\XINT_fcmp_D\expandafter
1864 {#3}{#1}{#2}%
1865 }%
1866 \def\XINT_fcmp_D #1#2#3%
1867 {%
1868 \expandafter\XINT_cntSgnFork\romannumeral- '0\expandafter\XINT_cntSgn
1869 \the\numexpr #2+\xintLength{#3}-\xintLength{#1}\relax\Z
1870 { -1}{\XINT_fcmp_E #2\Z {#3}{#1}}{ 1}%
1871 }%
1872 \def\XINT_fcmp_E #1%
1873 {%
1874 \xint_UDsignfork
1875 #1\XINT_fcmp_Fd
1876 -{\XINT_fcmp_Fn #1}%
1877 \krof
1878 }%
1879 \def\XINT_fcmp_Fd #1\Z #2#3%
1880 {%
1881 \expandafter\XINT_fcmp_Fe\expandafter
1882 {\romannumeral0\XINT_dsx_addzerosnofuss {#1}{#3}}{#2}%
1883 }%
1884 \def\XINT_fcmp_Fe #1#2{\XINT_cmp_pre {#2}{#1}}%
1885 \def\XINT_fcmp_Fn #1\Z #2#3%
1886 {%
1887 \expandafter\XINT_cmp_pre\expandafter
1888 {\romannumeral0\XINT_dsx_addzerosnofuss {#1}{#2}}{#3}%
1889 }%

```

### 39.52 \xintAbs

Simplified in 1.09i. (original macro was written before \xintRaw)

```

1890 \def\xintAbs {\romannumeral0\xintabs }%
1891 \def\xintabs #1{\expandafter\XINT_abs\romannumeral0\xintraw {#1}}%

```

**39.53 \xintOpp**

caution that `-#1` would not be ok if `#1` has `[n]` stuff. Simplified in 1.09i. (original macro was written before `\xintRaw`)

```
1892 \def\xintOpp    {\romannumeral0\xintopp }%
1893 \def\xintopp #1{\expandafter\XINT_opp\romannumeral0\xintraw {#1}}%
```

**39.54 \xintSgn**

Simplified in 1.09i. (original macro was written before `\xintRaw`)

```
1894 \def\xintSgn    {\romannumeral0\xintsgn }%
1895 \def\xintsgn #1{\expandafter\XINT_sgn\romannumeral0\xintraw {#1}\Z }%
```

**39.55 \xintFloatAdd, \XINTinFloatAdd**

1.07

```
1896 \def\xintFloatAdd    {\romannumeral0\xintfloatadd }%
1897 \def\xintfloatadd    #1{\XINT_fladd_chkopt \xintfloat #1\Z }%
1898 \def\XINTinFloatAdd  {\romannumeral0\XINTinfloatadd }%
1899 \def\XINTinfloatadd  #1{\XINT_fladd_chkopt \XINTinfloat #1\Z }%
1900 \def\XINT_fladd_chkopt #1#2%
1901 {%
1902     \ifx [#2\expandafter\XINT_fladd_opt
1903         \else\expandafter\XINT_fladd_noopt
1904     \fi #1#2%
1905 }%
1906 \def\XINT_fladd_noopt #1#2\Z #3%
1907 {%
1908     #1[\XINTdigits]{\XINT_FL_Add {\XINTdigits+2}{#2}{#3}}%
1909 }%
1910 \def\XINT_fladd_opt #1[\Z #2]#3#4%
1911 {%
1912     #1[#2]{\XINT_FL_Add {#2+2}{#3}{#4}}%
1913 }%
1914 \def\XINT_FL_Add #1#2%
1915 {%
1916     \expandafter\XINT_FL_Add_a\expandafter{\the\numexpr #1\expandafter}%
1917     \expandafter{\romannumeral0\XINTinfloat [#1]{#2}}%
1918 }%
1919 \def\XINT_FL_Add_a #1#2#3%
1920 {%
1921     \expandafter\XINT_FL_Add_b\romannumeral0\XINTinfloat [#1]{#3}#2{#1}%
1922 }%
1923 \def\XINT_FL_Add_b #1%
1924 {%
1925     \xint_gob_til_zero #1\XINT_FL_Add_zero 0\XINT_FL_Add_c #1%
```

```

1926 }%
1927 \def\XINT_FL_Add_c #1[#2]#3%
1928 {%
1929   \xint_gob_til_zero #3\XINT_FL_Add_zerobis 0\XINT_FL_Add_d #1[#2]#3%
1930 }%
1931 \def\XINT_FL_Add_d #1[#2]#3[#4]#5%
1932 {%
1933   \xintSgnFork {\ifnum \numexpr #2-#4-#5>1 \expandafter 1%
1934                 \else\ifnum \numexpr #4-#2-#5>1
1935                   \xint_afterfi {\expandafter-\expandafter1}%
1936                   \else \expandafter\expandafter\expandafter0%
1937                   \fi
1938                 \fi}%
1939   {#3[#4]}\xintAdd {#1[#2]}\{#3[#4]}\{#1[#2]}}%
1940 }%
1941 \def\XINT_FL_Add_zero 0\XINT_FL_Add_c 0[0]#1[#2]#3{#1[#2]}}%
1942 \def\XINT_FL_Add_zerobis 0\XINT_FL_Add_d #1[#2]0[0]#3{#1[#2]}}%

```

### 39.56 \xintFloatSub, \XINTinFloatSub

1.07

```

1943 \def\xintFloatSub {\romannumeral0\xintfloatsub }%
1944 \def\xintfloatsub #1{\XINT_flsub_chkopt \xintfloat #1\Z }%
1945 \def\XINTinFloatSub {\romannumeral0\XINTinfloatsub }%
1946 \def\XINTinfloatsub #1{\XINT_flsub_chkopt \XINTinfloat #1\Z }%
1947 \def\XINT_flsub_chkopt #1#2%
1948 {%
1949   \ifx [#2\expandafter\XINT_flsub_opt
1950   \else\expandafter\XINT_flsub_noopt
1951   \fi #1#2%
1952 }%
1953 \def\XINT_flsub_noopt #1#2\Z #3%
1954 {%
1955   #1[\XINTdigits]{\XINT_FL_Add {\XINTdigits+2}{#2}{\xintOpp{#3}}}%
1956 }%
1957 \def\XINT_flsub_opt #1[\Z #2]#3#4%
1958 {%
1959   #1[#2]{\XINT_FL_Add {#2+2}{#3}{\xintOpp{#4}}}%
1960 }%

```

### 39.57 \xintFloatMul, \XINTinFloatMul

1.07

```

1961 \def\xintFloatMul {\romannumeral0\xintfloatmul}%
1962 \def\xintfloatmul #1{\XINT_flmul_chkopt \xintfloat #1\Z }%
1963 \def\XINTinFloatMul {\romannumeral0\XINTinfloatmul }%

```

```

1964 \def\XINTinfloatmul #1{\XINT_flmul_chkopt \XINTinfloat #1\Z }%
1965 \def\XINT_flmul_chkopt #1#2%
1966 {%
1967   \ifx [#2\expandafter\XINT_flmul_opt
1968     \else\expandafter\XINT_flmul_noopt
1969   \fi #1#2%
1970 }%
1971 \def\XINT_flmul_noopt #1#2\Z #3%
1972 {%
1973   #1[\XINTdigits]{\XINT_FL_Mul {\XINTdigits+2}{#2}{#3}}%
1974 }%
1975 \def\XINT_flmul_opt #1[\Z #2]#3#4%
1976 {%
1977   #1[#2]{\XINT_FL_Mul {#2+2}{#3}{#4}}%
1978 }%
1979 \def\XINT_FL_Mul #1#2%
1980 {%
1981   \expandafter\XINT_FL_Mul_a\expandafter{\the\numexpr #1\expandafter}%
1982   \expandafter{\romannumeral0\XINTinfloat [#1]{#2}}%
1983 }%
1984 \def\XINT_FL_Mul_a #1#2#3%
1985 {%
1986   \expandafter\XINT_FL_Mul_b\romannumeral0\XINTinfloat [#1]{#3}#2%
1987 }%
1988 \def\XINT_FL_Mul_b #1[#2]#3[#4]{\xintE{\xintiiMul {#1}{#3}}{#2+#4}}%

```

### 39.58 \xintFloatDiv, \XINTinFloatDiv

1.07

```

1989 \def\xintFloatDiv {\romannumeral0\xintfloatdiv}%
1990 \def\xintfloatdiv #1{\XINT_fldiv_chkopt \xintfloat #1\Z }%
1991 \def\XINTinFloatDiv {\romannumeral0\XINTinfloatdiv }%
1992 \def\XINTinfloatdiv #1{\XINT_fldiv_chkopt \XINTinfloat #1\Z }%
1993 \def\XINT_fldiv_chkopt #1#2%
1994 {%
1995   \ifx [#2\expandafter\XINT_fldiv_opt
1996     \else\expandafter\XINT_fldiv_noopt
1997   \fi #1#2%
1998 }%
1999 \def\XINT_fldiv_noopt #1#2\Z #3%
2000 {%
2001   #1[\XINTdigits]{\XINT_FL_Div {\XINTdigits+2}{#2}{#3}}%
2002 }%
2003 \def\XINT_fldiv_opt #1[\Z #2]#3#4%
2004 {%
2005   #1[#2]{\XINT_FL_Div {#2+2}{#3}{#4}}%
2006 }%
2007 \def\XINT_FL_Div #1#2%

```

```

2008 {%
2009   \expandafter\XINT_FL_Div_a\expandafter{\the\numexpr #1\expandafter}%
2010   \expandafter{\romannumeral0\XINTinfloat [#1]{#2}}%
2011 }%
2012 \def\XINT_FL_Div_a #1#2#3%
2013 {%
2014   \expandafter\XINT_FL_Div_b\romannumeral0\XINTinfloat [#1]{#3}#2%
2015 }%
2016 \def\XINT_FL_Div_b #1[#2]#3[#4]{\xintE{#3/#1}{#4-#2}}%

```

### 39.59 \XINTinFloatSum

1.09a: quick write-up, for use by `\xintfloatexpr`, will need to be thought through again. Renamed (and slightly modified) in 1.09h. Should be extended for optional precision. Should be rewritten for optimization.

```

2017 \def\XINTinFloatSum {\romannumeral0\XINTinfloatsum }%
2018 \def\XINTinfloatsum #1{\expandafter\XINT_floatsum_a\romannumeral-‘0#1\relax }%
2019 \def\XINT_floatsum_a #1{\expandafter\XINT_floatsum_b
2020   \romannumeral0\XINTinfloat[\XINTdigits]{#1}\Z }%
2021 \def\XINT_floatsum_b #1\Z #2%
2022   {\expandafter\XINT_floatsum_c\romannumeral-‘0#2\Z {#1}\Z}%
2023 \def\XINT_floatsum_c #1%
2024   {\xint_gob_til_relax #1\XINT_floatsum_e\relax\XINT_floatsum_d #1}%
2025 \def\XINT_floatsum_d #1\Z
2026   {\expandafter\XINT_floatsum_b\romannumeral0\XINTinfloatadd {#1}}%
2027 \def\XINT_floatsum_e #1\Z #2\Z { #2}%

```

### 39.60 \XINTinFloatPrd

1.09a: quick write-up, for use by `\xintfloatexpr`, will need to be thought through again. Renamed (and slightly modified) in 1.09h. Should be extended for optional precision. Should be rewritten for optimization.

```

2028 \def\XINTinFloatPrd {\romannumeral0\XINTinfloatprd }%
2029 \def\XINTinfloatprd #1{\expandafter\XINT_floatprd_a\romannumeral-‘0#1\relax }%
2030 \def\XINT_floatprd_a #1{\expandafter\XINT_floatprd_b
2031   \romannumeral0\XINTinfloat[\XINTdigits]{#1}\Z }%
2032 \def\XINT_floatprd_b #1\Z #2%
2033   {\expandafter\XINT_floatprd_c\romannumeral-‘0#2\Z {#1}\Z}%
2034 \def\XINT_floatprd_c #1%
2035   {\xint_gob_til_relax #1\XINT_floatprd_e\relax\XINT_floatprd_d #1}%
2036 \def\XINT_floatprd_d #1\Z
2037   {\expandafter\XINT_floatprd_b\romannumeral0\XINTinfloatmul {#1}}%
2038 \def\XINT_floatprd_e #1\Z #2\Z { #2}%

```

**39.61 \xintFloatPow, \XINTinFloatPow**

1.07. Release 1.09j has re-organized the core loop, and \XINT\_flpow\_prd sub-routine has been removed.

```

2039 \def\xintFloatPow {\romannumeral0\xintfloatpow}%
2040 \def\xintfloatpow #1{\XINT_flpow_chkopt \xintfloat #1\Z }%
2041 \def\XINTinFloatPow {\romannumeral0\XINTinfloatpow }%
2042 \def\XINTinfloatpow #1{\XINT_flpow_chkopt \XINTinfloat #1\Z }%
2043 \def\XINT_flpow_chkopt #1#2%
2044 {%
2045   \ifx [#2\expandafter\XINT_flpow_opt
2046     \else\expandafter\XINT_flpow_noopt
2047   \fi
2048   #1#2%
2049 }%
2050 \def\XINT_flpow_noopt #1#2\Z #3%
2051 {%
2052   \expandafter\XINT_flpow_checkB_start\expandafter
2053     {\the\numexpr #3\expandafter}\expandafter
2054     {\the\numexpr \XINTdigits}{#2}{#1[\XINTdigits]]}%
2055 }%
2056 \def\XINT_flpow_opt #1[\Z #2]#3#4%
2057 {%
2058   \expandafter\XINT_flpow_checkB_start\expandafter
2059     {\the\numexpr #4\expandafter}\expandafter
2060     {\the\numexpr #2}{#3}{#1[#2]}%
2061 }%
2062 \def\XINT_flpow_checkB_start #1{\XINT_flpow_checkB_a #1\Z }%
2063 \def\XINT_flpow_checkB_a #1%
2064 {%
2065   \xint_UDzerominusfork
2066   #1-\XINT_flpow_BisZero
2067   0#1{\XINT_flpow_checkB_b 1}%
2068   0-{\XINT_flpow_checkB_b 0#1}%
2069   \krof
2070 }%
2071 \def\XINT_flpow_BisZero \Z #1#2#3{#3{1/1[0]}}%
2072 \def\XINT_flpow_checkB_b #1#2\Z #3%
2073 {%
2074   \expandafter\XINT_flpow_checkB_c \expandafter
2075     {\romannumeral0\xintlength{#2}}{#3}{#2}#1%
2076 }%
2077 \def\XINT_flpow_checkB_c #1#2%
2078 {%
2079   \expandafter\XINT_flpow_checkB_d \expandafter
2080     {\the\numexpr \expandafter\xintlength\expandafter
2081       {\the\numexpr #1*20/\xint_c_iii }+#1+#2+\xint_c_i }%
2082 }%

```

```

2083 \def\XINT_flpow_checkB_d #1#2#3#4%
2084 {%
2085   \expandafter \XINT_flpow_a
2086   \romannumeral0\XINTinfloat [#1]{#4}{#1}{#2}#3%
2087 }%
2088 \def\XINT_flpow_a #1%
2089 {%
2090   \xint_UDzerominusfork
2091   #1-\XINT_flpow_zero
2092   0#1{\XINT_flpow_b 1}%
2093   0-{\XINT_flpow_b 0#1}%
2094   \krof
2095 }%
2096 \def\XINT_flpow_b #1#2[#3]#4#5%
2097 {%
2098   \XINT_flpow_loopI {#5}{#2[#3]}\romannumeral0\XINTinfloatmul [#4]}%
2099   {#1*\ifodd #5 1\else 0\fi}%
2100 }%
2101 \def\XINT_flpow_zero [#1]#2#3#4#5%
2102 % xint is not equipped to signal infinity, the 2^31 will provoke
2103 % deliberately a number too big and arithmetic overflow in \XINT_float_Xb
2104 {%
2105   \if #41\xint_afterfi {\xintError:DivisionByZero #5{1[2147483648]}}%
2106   \else \xint_afterfi {#5{0[0]}}\fi
2107 }%
2108 \def\XINT_flpow_loopI #1%
2109 {%
2110   \ifnum #1=\xint_c_i\XINT_flpow_ItoIII\fi
2111   \ifodd #1
2112     \expandafter\XINT_flpow_loopI_odd
2113   \else
2114     \expandafter\XINT_flpow_loopI_even
2115   \fi
2116   {#1}%
2117 }%
2118 \def\XINT_flpow_ItoIII\fi #1\fi #2#3#4#5%
2119 {%
2120   \fi\expandafter\XINT_flpow_III\the\numexpr #5\relax #3%
2121 }%
2122 \def\XINT_flpow_loopI_even #1#2#3%
2123 {%
2124   \expandafter\XINT_flpow_loopI\expandafter
2125   {\the\numexpr #1/\xint_c_ii\expandafter}\expandafter
2126   {#3{#2}{#2}}{#3}%
2127 }%
2128 \def\XINT_flpow_loopI_odd #1#2#3%
2129 {%
2130   \expandafter\XINT_flpow_loopII\expandafter
2131   {\the\numexpr #1/\xint_c_ii-\xint_c_i\expandafter}\expandafter

```

```

2132   {#3{#2}{#2}}{#3}{#2}%
2133 }%
2134 \def\XINT_flpow_loopII #1%
2135 {%
2136   \ifnum #1 = \xint_c_i\XINT_flpow_IItoIII\fi
2137   \ifodd #1
2138     \expandafter\XINT_flpow_loopII_odd
2139   \else
2140     \expandafter\XINT_flpow_loopII_even
2141   \fi
2142   {#1}%
2143 }%
2144 \def\XINT_flpow_loopII_even #1#2#3%
2145 {%
2146   \expandafter\XINT_flpow_loopII\expandafter
2147   {\the\numexpr #1/\xint_c_ii\expandafter}\expandafter
2148   {#3{#2}{#2}}{#3}%
2149 }%
2150 \def\XINT_flpow_loopII_odd #1#2#3#4%
2151 {%
2152   \expandafter\XINT_flpow_loopII_odda\expandafter
2153   {#3{#2}{#4}}{#1}{#2}{#3}%
2154 }%
2155 \def\XINT_flpow_loopII_odda #1#2#3#4%
2156 {%
2157   \expandafter\XINT_flpow_loopII\expandafter
2158   {\the\numexpr #2/\xint_c_ii-\xint_c_i\expandafter}\expandafter
2159   {#4{#3}{#3}}{#4}{#1}%
2160 }%
2161 \def\XINT_flpow_IItoIII\fi #1\fi #2#3#4#5#6%
2162 {%
2163   \fi\expandafter\XINT_flpow_III\the\numexpr #6\expandafter\relax
2164   #4{#3}{#5}%
2165 }%
2166 \def\XINT_flpow_III #1#2[#3]#4%
2167 {%
2168   \expandafter\XINT_flpow_IIIend\expandafter
2169   {\the\numexpr\if #41 -\fi#3\expandafter}%
2170   \xint_UDzerofork
2171     #4{{#2}}%
2172     0{{1/#2}}%
2173   \krof #1%
2174 }%
2175 \def\XINT_flpow_IIIend #1#2#3#4%
2176 {%
2177   \xint_UDzerofork
2178   #3{#4{#2[#1]}}%
2179   0{#4{-#2[#1]}}%
2180   \krof

```

2181 }%

### 39.62 \xintFloatPower, \XINTinFloatPower

1.07. The core loop has been re-organized in 1.09j for some slight efficiency gain.

```

2182 \def\xintFloatPower {\romannumeral0\xintfloatpower}%
2183 \def\xintfloatpower #1{\XINT_flpower_chkopt \xintfloat #1\Z }%
2184 \def\XINTinFloatPower {\romannumeral0\XINTinfloatpower}%
2185 \def\XINTinfloatpower #1{\XINT_flpower_chkopt \XINTinfloat #1\Z }%
2186 \def\XINT_flpower_chkopt #1#2%
2187 {%
2188   \ifx [#2\expandafter\XINT_flpower_opt
2189     \else\expandafter\XINT_flpower_noopt
2190   \fi
2191   #1#2%
2192 }%
2193 \def\XINT_flpower_noopt #1#2\Z #3%
2194 {%
2195   \expandafter\XINT_flpower_checkB_start\expandafter
2196     {\the\numexpr \XINTdigits\expandafter}\expandafter
2197     {\romannumeral0\xintnum{#3}}{#2}{#1[\XINTdigits]}%
2198 }%
2199 \def\XINT_flpower_opt #1[\Z #2]#3#4%
2200 {%
2201   \expandafter\XINT_flpower_checkB_start\expandafter
2202     {\the\numexpr #2\expandafter}\expandafter
2203     {\romannumeral0\xintnum{#4}}{#3}{#1[#2]}%
2204 }%
2205 \def\XINT_flpower_checkB_start #1#2{\XINT_flpower_checkB_a #2\Z {#1}}%
2206 \def\XINT_flpower_checkB_a #1%
2207 {%
2208   \xint_UDzerominusfork
2209   #1-\XINT_flpower_BisZero
2210   0#1{\XINT_flpower_checkB_b 1}%
2211   0-{\XINT_flpower_checkB_b 0#1}%
2212   \krof
2213 }%
2214 \def\XINT_flpower_BisZero \Z #1#2#3{#3{1/1[0]}}%
2215 \def\XINT_flpower_checkB_b #1#2\Z #3%
2216 {%
2217   \expandafter\XINT_flpower_checkB_c \expandafter
2218     {\romannumeral0\xintlengh{#2}}{#3}{#2}#1%
2219 }%
2220 \def\XINT_flpower_checkB_c #1#2%
2221 {%
2222   \expandafter\XINT_flpower_checkB_d \expandafter
2223     {\the\numexpr \expandafter\xintLength\expandafter

```

### 39 Package *xintfrac* implementation

```

2224          {\the\numexpr #1*20/\xint_c_iii }+#1+#2+\xint_c_i }%
2225 }%
2226 \def\xINT_flpower_checkB_d #1#2#3#4%
2227 {%
2228   \expandafter \XINT_flpower_a
2229   \romannumeral0\xINTinfloat [#1]{#4}{#1}{#2}#3%
2230 }%
2231 \def\xINT_flpower_a #1%
2232 {%
2233   \xint_UDzerominusfork
2234   #1-\XINT_flpow_zero
2235   0#1{\XINT_flpower_b 1}%
2236   0-{\XINT_flpower_b 0#1}%
2237   \krof
2238 }%
2239 \def\xINT_flpower_b #1#2[#3]#4#5%
2240 {%
2241   \XINT_flpower_loopI {#5}{#2[#3]}\romannumeral0\xINTinfloatmul [#4]}%
2242   {#1*\xintiiOdd {#5}}%
2243 }%
2244 \def\xINT_flpower_loopI #1%
2245 {%
2246   \if1\xINT_isOne {#1}\XINT_flpower_ItoIII\fi
2247   \if1\xintiiOdd{#1}%
2248     \expandafter\expandafter\expandafter\xINT_flpower_loopI_odd
2249   \else
2250     \expandafter\expandafter\expandafter\xINT_flpower_loopI_even
2251   \fi
2252   \expandafter {\romannumeral0\xinthalff{#1}}%
2253 }%
2254 \def\xINT_flpower_ItoIII\fi #1\fi\expandafter #2#3#4#5%
2255 {%
2256   \fi\expandafter\xINT_flpow_III \the\numexpr #5\relax #3%
2257 }%
2258 \def\xINT_flpower_loopI_even #1#2#3%
2259 {%
2260   \expandafter\xINT_flpower_toI\expandafter {#3{#2}{#2}}{#1}{#3}%
2261 }%
2262 \def\xINT_flpower_loopI_odd #1#2#3%
2263 {%
2264   \expandafter\xINT_flpower_toII\expandafter {#3{#2}{#2}}{#1}{#3}{#2}%
2265 }%
2266 \def\xINT_flpower_toI #1#2{\XINT_flpower_loopI {#2}{#1}}%
2267 \def\xINT_flpower_toII #1#2{\XINT_flpower_loopII {#2}{#1}}%
2268 \def\xINT_flpower_loopII #1%
2269 {%
2270   \if1\xINT_isOne {#1}\XINT_flpower_IItoIII\fi
2271   \if1\xintiiOdd{#1}%
2272     \expandafter\expandafter\expandafter\xINT_flpower_loopII_odd

```

```

2273 \else
2274 \expandafter\expandafter\expandafter\XINT_flpower_loopII_even
2275 \fi
2276 \expandafter {\romannumeral0\xinthalff{#1}}%
2277 }%
2278 \def\XINT_flpower_loopII_even #1#2#3%
2279 {%
2280 \expandafter\XINT_flpower_toII\expandafter
2281 {#3{#2}{#2}}{#1}{#3}%
2282 }%
2283 \def\XINT_flpower_loopII_odd #1#2#3#4%
2284 {%
2285 \expandafter\XINT_flpower_loopII_odda\expandafter
2286 {#3{#2}{#4}}{#2}{#3}{#1}%
2287 }%
2288 \def\XINT_flpower_loopII_odda #1#2#3#4%
2289 {%
2290 \expandafter\XINT_flpower_toII\expandafter
2291 {#3{#2}{#2}}{#4}{#3}{#1}%
2292 }%
2293 \def\XINT_flpower_IItoIII\fi #1\fi\expandafter #2#3#4#5#6%
2294 {%
2295 \fi\expandafter\XINT_flpow_III\the\numexpr #6\expandafter\relax
2296 #4{#3}{#5}%
2297 }%

```

### 39.63 \xintFloatSqrt, \XINTinFloatSqrt

1.08

```

2298 \def\xintFloatSqrt {\romannumeral0\xintfloatsqrt }%
2299 \def\xintfloatsqrt #1{\XINT_flsqrt_chkopt \xintfloat #1\Z }%
2300 \def\XINTinFloatSqrt {\romannumeral0\XINTinfloatsqrt }%
2301 \def\XINTinfloatsqrt #1{\XINT_flsqrt_chkopt \XINTinfloat #1\Z }%
2302 \def\XINT_flsqrt_chkopt #1#2%
2303 {%
2304 \ifx [#2\expandafter\XINT_flsqrt_opt
2305 \else\expandafter\XINT_flsqrt_noopt
2306 \fi #1#2%
2307 }%
2308 \def\XINT_flsqrt_noopt #1#2\Z
2309 {%
2310 #1[\XINTdigits]{\XINT_FL_sqrt \XINTdigits {#2}}%
2311 }%
2312 \def\XINT_flsqrt_opt #1[\Z #2]#3%
2313 {%
2314 #1[#2]{\XINT_FL_sqrt {#2}{#3}}%
2315 }%
2316 \def\XINT_FL_sqrt #1%

```

```

2317 {%
2318   \ifnum\numexpr #1<\xint_c_xviii
2319     \xint_afterfi {\XINT_FL_sqrt_a\xint_c_xviii}%
2320   \else
2321     \xint_afterfi {\XINT_FL_sqrt_a {\#1+\xint_c_i}}%
2322   \fi
2323 }%
2324 \def\XINT_FL_sqrt_a #1#2%
2325 {%
2326   \expandafter\XINT_FL_sqrt_checkifzeroorneg
2327   \romannumeral0\XINTinfloat [#1]{#2}%
2328 }%
2329 \def\XINT_FL_sqrt_checkifzeroorneg #1%
2330 {%
2331   \xint_UDzerominusfork
2332   #1-\XINT_FL_sqrt_iszero
2333   0#1\XINT_FL_sqrt_isneg
2334   0-{\XINT_FL_sqrt_b #1}%
2335   \krof
2336 }%
2337 \def\XINT_FL_sqrt_iszero #1[#2]{0[0]}%
2338 \def\XINT_FL_sqrt_isneg #1[#2]{\xintError:RootOfNegative 0[0]}%
2339 \def\XINT_FL_sqrt_b #1[#2]%
2340 {%
2341   \ifodd #2
2342     \xint_afterfi{\XINT_FL_sqrt_c 01}%
2343   \else
2344     \xint_afterfi{\XINT_FL_sqrt_c {}0}%
2345   \fi
2346   {#1}{#2}%
2347 }%
2348 \def\XINT_FL_sqrt_c #1#2#3#4%
2349 {%
2350   \expandafter\XINT_flsqrt\expandafter {\the\numexpr #4-#2}{#3#1}%
2351 }%
2352 \def\XINT_flsqrt #1#2%
2353 {%
2354   \expandafter\XINT_sqrt_a
2355   \expandafter{\romannumeral0\xintlength {#2}}\XINT_flsqrt_big_d {#2}{#1}%
2356 }%
2357 \def\XINT_flsqrt_big_d #1#2%
2358 {%
2359   \ifodd #2
2360     \expandafter\expandafter\expandafter\XINT_flsqrt_big_eB
2361   \else
2362     \expandafter\expandafter\expandafter\XINT_flsqrt_big_eA
2363   \fi
2364   \expandafter {\the\numexpr (#2-\xint_c_i)/\xint_c_ii }{#1}%
2365 }%

```

```

2366 \def\XINT_flsqrt_big_eA #1#2#3%
2367 {%
2368   \XINT_flsqrt_big_eA_a #3\Z {#2}{#1}{#3}%
2369 }%
2370 \def\XINT_flsqrt_big_eA_a #1#2#3#4#5#6#7#8#9\Z
2371 {%
2372   \XINT_flsqrt_big_eA_b {#1#2#3#4#5#6#7#8}%
2373 }%
2374 \def\XINT_flsqrt_big_eA_b #1#2%
2375 {%
2376   \expandafter\XINT_flsqrt_big_f
2377   \romannumeral0\XINT_flsqrt_small_e {#2001}{#1}%
2378 }%
2379 \def\XINT_flsqrt_big_eB #1#2#3%
2380 {%
2381   \XINT_flsqrt_big_eB_a #3\Z {#2}{#1}{#3}%
2382 }%
2383 \def\XINT_flsqrt_big_eB_a #1#2#3#4#5#6#7#8#9%
2384 {%
2385   \XINT_flsqrt_big_eB_b {#1#2#3#4#5#6#7#8#9}%
2386 }%
2387 \def\XINT_flsqrt_big_eB_b #1#2\Z #3%
2388 {%
2389   \expandafter\XINT_flsqrt_big_f
2390   \romannumeral0\XINT_flsqrt_small_e {#30001}{#1}%
2391 }%
2392 \def\XINT_flsqrt_small_e #1#2%
2393 {%
2394   \expandafter\XINT_flsqrt_small_f\expandafter
2395   {\the\numexpr #1*#1-#2-\xint_c_i}{#1}%
2396 }%
2397 \def\XINT_flsqrt_small_f #1#2%
2398 {%
2399   \expandafter\XINT_flsqrt_small_g\expandafter
2400   {\the\numexpr (#1+#2)/(2*#2)-\xint_c_i }{#1}{#2}%
2401 }%
2402 \def\XINT_flsqrt_small_g #1%
2403 {%
2404   \ifnum #1>\xint_c_
2405     \expandafter\XINT_flsqrt_small_h
2406   \else
2407     \expandafter\XINT_flsqrt_small_end
2408   \fi
2409   {#1}%
2410 }%
2411 \def\XINT_flsqrt_small_h #1#2#3%
2412 {%
2413   \expandafter\XINT_flsqrt_small_f\expandafter
2414   {\the\numexpr #2-\xint_c_ii*#1*#3+#1*#1\expandafter}\expandafter

```

```

2415   {\the\numexpr #3-#1}%
2416 }%
2417 \def\XINT_flsqrt_small_end #1#2#3%
2418 {%
2419   \expandafter\space\expandafter
2420   {\the\numexpr \xint_c_i+#3*\xint_c_x^iv-
2421     (#2*\xint_c_x^iv+#3)/(\xint_c_ii*#3)}%
2422 }%
2423 \def\XINT_flsqrt_big_f #1%
2424 {%
2425   \expandafter\XINT_flsqrt_big_fa\expandafter
2426   {\romannumeral0\xintiisqr {#1}}{#1}%
2427 }%
2428 \def\XINT_flsqrt_big_fa #1#2#3#4%
2429 {%
2430   \expandafter\XINT_flsqrt_big_fb\expandafter
2431   {\romannumeral0\XINT_dsx_addzerosnofuss
2432     {\numexpr #3-\xint_c_viii\relax}{#2}}%
2433   {\romannumeral0\xintiisub
2434     {\XINT_dsx_addzerosnofuss
2435       {\numexpr \xint_c_ii*(#3-\xint_c_viii)\relax}{#1}}{#4}}%
2436   {#3}%
2437 }%
2438 \def\XINT_flsqrt_big_fb #1#2%
2439 {%
2440   \expandafter\XINT_flsqrt_big_g\expandafter {#2}{#1}%
2441 }%
2442 \def\XINT_flsqrt_big_g #1#2%
2443 {%
2444   \expandafter\XINT_flsqrt_big_j
2445   \romannumeral0\xintiidivision
2446   {#1}{\romannumeral0\XINT_dbl_pos #2\R\R\R\R\R\R\R\Z \W\W\W\W\W\W\W }{#2}%
2447 }%
2448 \def\XINT_flsqrt_big_j #1%
2449 {%
2450   \if0\XINT_Sgn #1\Z
2451     \expandafter \XINT_flsqrt_big_end_a
2452   \else \expandafter \XINT_flsqrt_big_k
2453   \fi {#1}%
2454 }%
2455 \def\XINT_flsqrt_big_k #1#2#3%
2456 {%
2457   \expandafter\XINT_flsqrt_big_l\expandafter
2458   {\romannumeral0\XINT_sub_pre {#3}}{#1}}%
2459   {\romannumeral0\xintiiadd {#2}}{\romannumeral0\XINT_sqr {#1}}}%
2460 }%
2461 \def\XINT_flsqrt_big_l #1#2%
2462 {%
2463   \expandafter\XINT_flsqrt_big_g\expandafter

```

```

2464    {#2}{#1}%
2465 }%
2466 \def\XINT_flsqrt_big_end_a #1#2#3#4#5%
2467 {%
2468   \expandafter\XINT_flsqrt_big_end_b\expandafter
2469   {\the\numexpr -#4+#5/\xint_c_ii\expandafter}\expandafter
2470   {\romannumeral0\xintiisub
2471    {\XINT_dsx_addzerosnofuss {#4}{#3}}}%
2472    {\xintHalf{\xintiiQuo{\XINT_dsx_addzerosnofuss {#4}{#2}}{#3}}}%
2473 }%
2474 \def\XINT_flsqrt_big_end_b #1#2{#2[#1]}%

```

### 39.64 \XINTinFloatMaxof

1.09a, for use by \xintNewFloatExpr. Name changed in 1.09h

```

2475 \def\XINTinFloatMaxof {\romannumeral0\XINTinfloatmaxof }%
2476 \def\XINTinfloatmaxof #1{\expandafter\XINT_flmaxof_a\romannumeral-‘0#1\relax }%
2477 \def\XINT_flmaxof_a #1{\expandafter\XINT_flmaxof_b
2478   \romannumeral0\XINTinfloat [\XINTdigits]{#1}\Z }%
2479 \def\XINT_flmaxof_b #1\Z #2%
2480   {\expandafter\XINT_flmaxof_c\romannumeral-‘0#2\Z {#1}\Z}%
2481 \def\XINT_flmaxof_c #1%
2482   {\xint_gob_til_relax #1\XINT_flmaxof_e\relax\XINT_flmaxof_d #1}%
2483 \def\XINT_flmaxof_d #1\Z
2484   {\expandafter\XINT_flmaxof_b\romannumeral0\xintmax
2485    {\XINTinFloat [\XINTdigits]{#1}}}%
2486 \def\XINT_flmaxof_e #1\Z #2\Z { #2}%

```

### 39.65 \XINTinFloatMinof

1.09a, for use by \xintNewFloatExpr. Name changed in 1.09h

```

2487 \def\XINTinFloatMinof {\romannumeral0\XINTinfloatminof }%
2488 \def\XINTinfloatminof #1{\expandafter\XINT_flminof_a\romannumeral-‘0#1\relax }%
2489 \def\XINT_flminof_a #1{\expandafter\XINT_flminof_b
2490   \romannumeral0\XINTinfloat [\XINTdigits]{#1}\Z }%
2491 \def\XINT_flminof_b #1\Z #2%
2492   {\expandafter\XINT_flminof_c\romannumeral-‘0#2\Z {#1}\Z}%
2493 \def\XINT_flminof_c #1%
2494   {\xint_gob_til_relax #1\XINT_flminof_e\relax\XINT_flminof_d #1}%
2495 \def\XINT_flminof_d #1\Z
2496   {\expandafter\XINT_flminof_b\romannumeral0\xintmin
2497    {\XINTinFloat [\XINTdigits]{#1}}}%
2498 \def\XINT_flminof_e #1\Z #2\Z { #2}%

```

### 39.66 \xintRound:csv

1.09a. For use by \xinttheiexpr.

```

2499 \def\xintRound:csv #1{\expandafter\XINT_round:_a\romannumeral-‘0#1,,^}%
2500 \def\XINT_round:_a {\XINT_round:_b {}}}%
2501 \def\XINT_round:_b #1#2,%
2502         {\expandafter\XINT_round:_c\romannumeral-‘0#2,{#1}}}%
2503 \def\XINT_round:_c #1{\if #1,\expandafter\XINT_:_f
2504         \else\expandafter\XINT_round:_d\fi #1}%
2505 \def\XINT_round:_d #1,%
2506         {\expandafter\XINT_round:_e\romannumeral0\xintiround 0{#1},}%
2507 \def\XINT_round:_e #1,#2{\XINT_round:_b {#2,#1}}}%

```

**39.67 \xintFloat:csv**

1.09a. For use by \xintthefloatexpr.

```

2508 \def\xintFloat:csv #1{\expandafter\XINT_float:_a\romannumeral-‘0#1,,^}%
2509 \def\XINT_float:_a {\XINT_float:_b {}}}%
2510 \def\XINT_float:_b #1#2,%
2511         {\expandafter\XINT_float:_c\romannumeral-‘0#2,{#1}}}%
2512 \def\XINT_float:_c #1{\if #1,\expandafter\XINT_:_f
2513         \else\expandafter\XINT_float:_d\fi #1}%
2514 \def\XINT_float:_d #1,%
2515         {\expandafter\XINT_float:_e\romannumeral0\xintfloat {#1},}%
2516 \def\XINT_float:_e #1,#2{\XINT_float:_b {#2,#1}}}%

```

**39.68 \xintSum:csv**

1.09a. For use by \xintexpr.

```

2517 \def\xintSum:csv #1{\expandafter\XINT_sum:_a\romannumeral-‘0#1,,^}%
2518 \def\XINT_sum:_a {\XINT_sum:_b {0/1[0]}}}%
2519 \def\XINT_sum:_b #1#2,{\expandafter\XINT_sum:_c\romannumeral-‘0#2,{#1}}}%
2520 \def\XINT_sum:_c #1{\if #1,\expandafter\XINT_:_e
2521         \else\expandafter\XINT_sum:_d\fi #1}%
2522 \def\XINT_sum:_d #1,#2{\expandafter\XINT_sum:_b\expandafter
2523         {\romannumeral0\xintadd {#2}{#1}}}%

```

**39.69 \xintPrd:csv**

1.09a. For use by \xintexpr.

```

2524 \def\xintPrd:csv #1{\expandafter\XINT_prd:_a\romannumeral-‘0#1,,^}%
2525 \def\XINT_prd:_a {\XINT_prd:_b {1/1[0]}}}%
2526 \def\XINT_prd:_b #1#2,{\expandafter\XINT_prd:_c\romannumeral-‘0#2,{#1}}}%
2527 \def\XINT_prd:_c #1{\if #1,\expandafter\XINT_:_e
2528         \else\expandafter\XINT_prd:_d\fi #1}%
2529 \def\XINT_prd:_d #1,#2{\expandafter\XINT_prd:_b\expandafter
2530         {\romannumeral0\xintmul {#2}{#1}}}%

```

**39.70 \xintMaxof:csv**

1.09a. For use by \xintexpr. Even with only one argument, there does not seem to be really a motive for using \xintrow?

```

2531 \def\xintMaxof:csv #1{\expandafter\XINT_maxof:_b\romannumeral-‘0#1,,}%
2532 \def\XINT_maxof:_b #1,#2,{\expandafter\XINT_maxof:_c\romannumeral-‘0#2,{#1},}%
2533 \def\XINT_maxof:_c #1{\if #1,\expandafter\XINT_of:_e
2534         \else\expandafter\XINT_maxof:_d\fi #1}%
2535 \def\XINT_maxof:_d #1,{\expandafter\XINT_maxof:_b\romannumeral0\xintmax {#1}}%
```

**39.71 \xintMinof:csv**

1.09a. For use by \xintexpr.

```

2536 \def\xintMinof:csv #1{\expandafter\XINT_minof:_b\romannumeral-‘0#1,,}%
2537 \def\XINT_minof:_b #1,#2,{\expandafter\XINT_minof:_c\romannumeral-‘0#2,{#1},}%
2538 \def\XINT_minof:_c #1{\if #1,\expandafter\XINT_of:_e
2539         \else\expandafter\XINT_minof:_d\fi #1}%
2540 \def\XINT_minof:_d #1,{\expandafter\XINT_minof:_b\romannumeral0\xintmin {#1}}%
```

**39.72 \XINTinFloatMinof:csv**

1.09a. For use by \xintfloatexpr. Name changed in 1.09h

```

2541 \def\XINTinFloatMinof:csv #1{\expandafter\XINT_flminof:_a\romannumeral-‘0#1,,}%
2542 \def\XINT_flminof:_a #1,{\expandafter\XINT_flminof:_b
2543         \romannumeral0\XINTinfloat [\XINTdigits]{#1},}%
2544 \def\XINT_flminof:_b #1,#2,%
2545         {\expandafter\XINT_flminof:_c\romannumeral-‘0#2,{#1},}%
2546 \def\XINT_flminof:_c #1{\if #1,\expandafter\XINT_of:_e
2547         \else\expandafter\XINT_flminof:_d\fi #1}%
2548 \def\XINT_flminof:_d #1,%
2549         {\expandafter\XINT_flminof:_b\romannumeral0\xintmin
2550         {\XINTinFloat [\XINTdigits]{#1}}}%

```

**39.73 \XINTinFloatMaxof:csv**

1.09a. For use by \xintfloatexpr. Name changed in 1.09h

```

2551 \def\XINTinFloatMaxof:csv #1{\expandafter\XINT_flmaxof:_a\romannumeral-‘0#1,,}%
2552 \def\XINT_flmaxof:_a #1,{\expandafter\XINT_flmaxof:_b
2553         \romannumeral0\XINTinfloat [\XINTdigits]{#1},}%
2554 \def\XINT_flmaxof:_b #1,#2,%
2555         {\expandafter\XINT_flmaxof:_c\romannumeral-‘0#2,{#1},}%
2556 \def\XINT_flmaxof:_c #1{\if #1,\expandafter\XINT_of:_e
2557         \else\expandafter\XINT_flmaxof:_d\fi #1}%
2558 \def\XINT_flmaxof:_d #1,%
2559         {\expandafter\XINT_flmaxof:_b\romannumeral0\xintmax
2560         {\XINTinFloat [\XINTdigits]{#1}}}%

```

**39.74 \XINTinFloatSum:csv**

1.09a. For use by \xintfloatexpr. Renamed in 1.09h

```

2561 \def\XINTinFloatSum:csv #1{\expandafter\XINT_floatsum:_a\romannumeral-‘0#1,,^}%
2562 \def\XINT_floatsum:_a {\XINT_floatsum:_b {0[0]}}}%
2563 \def\XINT_floatsum:_b #1#2,%
2564         {\expandafter\XINT_floatsum:_c\romannumeral-‘0#2,{#1}}}%
2565 \def\XINT_floatsum:_c #1{\if #1,\expandafter\XINT_:_e
2566         \else\expandafter\XINT_floatsum:_d\fi #1}%
2567 \def\XINT_floatsum:_d #1,#2{\expandafter\XINT_floatsum:_b\expandafter
2568         {\romannumeral0\XINTinfloatadd {#2}{#1}}}%

```

**39.75 \XINTinFloatPrd:csv**

1.09a. For use by \xintfloatexpr. Renamed in 1.09h

```

2569 \def\XINTinFloatPred:csv #1{\expandafter\XINT_floatprd:_a\romannumeral-‘0#1,,^}%
2570 \def\XINT_floatprd:_a {\XINT_floatprd:_b {1[0]}}}%
2571 \def\XINT_floatprd:_b #1#2,%
2572         {\expandafter\XINT_floatprd:_c\romannumeral-‘0#2,{#1}}}%
2573 \def\XINT_floatprd:_c #1{\if #1,\expandafter\XINT_:_e
2574         \else\expandafter\XINT_floatprd:_d\fi #1}%
2575 \def\XINT_floatprd:_d #1,#2{\expandafter\XINT_floatprd:_b\expandafter
2576         {\romannumeral0\XINTinfloatmul {#2}{#1}}}%
2577 \XINT_restorecatcodes_endinput%

```

**40 Package **xintseries** implementation**

The commenting is currently (2014/01/09) very sparse.

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**40.1 Catcodes,  $\varepsilon$ -T<sub>E</sub>X and reload detection**

The code for reload detection is copied from HEIKO OBERDIEK’s packages, and adapted here to check for previous loading of the **xintfrac** package.

The method for catcodes is slightly different, but still directly inspired by these packages.

```

1 \begingroup\catcode61\catcode48\catcode32=10\relax%
2  \catcode13=5      % ^^M
3  \endlinechar=13 %
4  \catcode123=1     % {
5  \catcode125=2     % }
6  \catcode64=11     % @
7  \catcode35=6      % #
8  \catcode44=12     % ,
9  \catcode45=12     % -
10 \catcode46=12     % .
11 \catcode58=12     % :
12 \def\space { }%
13 \let\z\endgroup
14 \expandafter\let\expandafter\x\csname ver@xintseries.sty\endcsname
15 \expandafter\let\expandafter\w\csname ver@xintfrac.sty\endcsname
16 \expandafter
17   \ifx\csname PackageInfo\endcsname\relax
18     \def\y#1#2{\immediate\write-1{Package #1 Info: #2.}}%
19   \else
20     \def\y#1#2{\PackageInfo{#1}{#2}}%
21   \fi
22 \expandafter
23 \ifx\csname numexpr\endcsname\relax
24   \y{xintseries}{\numexpr not available, aborting input}%
25   \aftergroup\endinput
26 \else
27   \ifx\x\relax    % plain-TeX, first loading of xintseries.sty
28     \ifx\w\relax % but xintfrac.sty not yet loaded.
29       \y{xintseries}{now issuing \string\input\space xintfrac.sty}%
30       \def\z{\endgroup\input xintfrac.sty\relax}%
31     \fi
32   \else
33     \def\empty {}%
34     \ifx\x\empty % LaTeX, first loading,
35     % variable is initialized, but \ProvidesPackage not yet seen
36     \ifx\w\relax % xintfrac.sty not yet loaded.
37       \y{xintseries}{now issuing \string\RequirePackage{xintfrac}}%
38       \def\z{\endgroup\RequirePackage{xintfrac}}%
39     \fi
40   \else
41     \y{xintseries}{I was already loaded, aborting input}%
42     \aftergroup\endinput
43   \fi
44 \fi
45 \fi
46 \z%
```

**40.2 Confirmation of *xintfrac* loading**

```

47 \begingroup\catcode61\catcode48\catcode32=10\relax%
48 \catcode13=5 % ^^M
49 \endlinechar=13 %
50 \catcode123=1 % {
51 \catcode125=2 % }
52 \catcode64=11 % @
53 \catcode35=6 % #
54 \catcode44=12 % ,
55 \catcode45=12 % -
56 \catcode46=12 % .
57 \catcode58=12 % :
58 \ifdefined\PackageInfo
59 \def\y#1#2{\PackageInfo{#1}{#2}}%
60 \else
61 \def\y#1#2{\immediate\write-1{Package #1 Info: #2.}}%
62 \fi
63 \def\empty {}%
64 \expandafter\let\expandafter\w\csname ver@xintfrac.sty\endcsname
65 \ifx\w\relax % Plain TeX, user gave a file name at the prompt
66 \y{xintseries}{Loading of package xintfrac failed, aborting input}%
67 \aftergroup\endinput
68 \fi
69 \ifx\w\empty % LaTeX, user gave a file name at the prompt
70 \y{xintseries}{Loading of package xintfrac failed, aborting input}%
71 \aftergroup\endinput
72 \fi
73 \endgroup%

```

**40.3 Catcodes**

```

74 \XINTsetupcatcodes%

```

**40.4 Package identification**

```

75 \XINT_providespackage
76 \ProvidesPackage{xintseries}%
77 [2014/01/09 v1.09j Expandable partial sums with xint package (jfb)]%

```

**40.5 *\xintSeries***

Modified in 1.06 to give the indices first to a `\numexpr` rather than expanding twice. I just use `\the\numexpr` and maintain the previous code after that. 1.08a adds the forgotten optimization following that previous change.

```

78 \def\xintSeries {\romannumeral0\xintseries }%
79 \def\xintseries #1#2%
80 {%
81 \expandafter\XINT_series\expandafter
82 {\the\numexpr #1\expandafter}\expandafter{\the\numexpr #2}%
83 }%

```

```

84 \def\XINT_series #1#2#3%
85 {%
86   \ifnum #2<#1
87     \xint_afterfi { 0/1[0]}%
88   \else
89     \xint_afterfi {\XINT_series_loop {#1}{0}{#2}{#3}}%
90   \fi
91 }%
92 \def\XINT_series_loop #1#2#3#4%
93 {%
94   \ifnum #3>#1 \else \XINT_series_exit \fi
95   \expandafter\XINT_series_loop\expandafter
96   {\the\numexpr #1+1\expandafter }\expandafter
97   {\romannumeral0\xintadd {#2}{#4{#1}}}%
98   {#3}{#4}%
99 }%
100 \def\XINT_series_exit \fi #1#2#3#4#5#6#7#8%
101 {%
102   \fi\xint_gobble_ii #6%
103 }%

```

## 40.6 \xintiSeries

Modified in 1.06 to give the indices first to a `\numexpr` rather than expanding twice. I just use `\the\numexpr` and maintain the previous code after that. 1.08a adds the forgotten optimization following that previous change.

```

104 \def\xintiSeries {\romannumeral0\xintiseries }%
105 \def\xintiseries #1#2%
106 {%
107   \expandafter\XINT_iseries\expandafter
108   {\the\numexpr #1\expandafter}\expandafter{\the\numexpr #2}%
109 }%
110 \def\XINT_iseries #1#2#3%
111 {%
112   \ifnum #2<#1
113     \xint_afterfi { 0}%
114   \else
115     \xint_afterfi {\XINT_iseries_loop {#1}{0}{#2}{#3}}%
116   \fi
117 }%
118 \def\XINT_iseries_loop #1#2#3#4%
119 {%
120   \ifnum #3>#1 \else \XINT_iseries_exit \fi
121   \expandafter\XINT_iseries_loop\expandafter
122   {\the\numexpr #1+1\expandafter }\expandafter
123   {\romannumeral0\xintiiadd {#2}{#4{#1}}}%
124   {#3}{#4}%
125 }%

```

```

126 \def\XINT_iseries_exit \fi #1#2#3#4#5#6#7#8%
127 {%
128     \fi\xint_gobble_ii #6%
129 }%

```

## 40.7 \xintPowerSeries

The 1.03 version was very lame and created a build-up of denominators. The Horner scheme for polynomial evaluation is used in 1.04, this cures the denominator problem and drastically improves the efficiency of the macro. Modified in 1.06 to give the indices first to a \numexpr rather than expanding twice. I just use \the\numexpr and maintain the previous code after that. 1.08a adds the forgotten optimization following that previous change.

```

130 \def\xintPowerSeries {\romannumeral0\xintpowerseries }%
131 \def\xintpowerseries #1#2%
132 {%
133     \expandafter\XINT_powseries\expandafter
134     {\the\numexpr #1\expandafter}\expandafter{\the\numexpr #2}%
135 }%
136 \def\XINT_powseries #1#2#3#4%
137 {%
138     \ifnum #2<#1
139         \xint_afterfi { 0/1[0]}%
140     \else
141         \xint_afterfi
142         {\XINT_powseries_loop_i {#3{#2}}{#1}{#2}{#3}{#4}}%
143     \fi
144 }%
145 \def\XINT_powseries_loop_i #1#2#3#4#5%
146 {%
147     \ifnum #3>#2 \else\XINT_powseries_exit_i\fi
148     \expandafter\XINT_powseries_loop_ii\expandafter
149     {\the\numexpr #3-1\expandafter}\expandafter
150     {\romannumeral0\xintmul {#1}{#5}}{#2}{#4}{#5}%
151 }%
152 \def\XINT_powseries_loop_ii #1#2#3#4%
153 {%
154     \expandafter\XINT_powseries_loop_i\expandafter
155     {\romannumeral0\xintadd {#4{#1}}{#2}}{#3}{#1}{#4}%
156 }%
157 \def\XINT_powseries_exit_i\fi #1#2#3#4#5#6#7#8#9%
158 {%
159     \fi \XINT_powseries_exit_ii #6{#7}%
160 }%
161 \def\XINT_powseries_exit_ii #1#2#3#4#5#6%
162 {%
163     \xintmul{\xintPow {#5}{#6}}{#4}%
164 }%

```

## 40.8 \xintPowerSeriesX

Same as \xintPowerSeries except for the initial expansion of the x parameter. Modified in 1.06 to give the indices first to a \numexpr rather than expanding twice. I just use \the\numexpr and maintain the previous code after that. 1.08a adds the forgotten optimization following that previous change.

```

165 \def\xintPowerSeriesX {\romannumeral0\xintpowerseriesx }%
166 \def\xintpowerseriesx #1#2%
167 {%
168   \expandafter\XINT_powseriesx\expandafter
169   {\the\numexpr #1\expandafter}\expandafter{\the\numexpr #2}%
170 }%
171 \def\XINT_powseriesx #1#2#3#4%
172 {%
173   \ifnum #2<#1
174     \xint_afterfi { 0/1[0]}%
175   \else
176     \xint_afterfi
177     {\expandafter\XINT_powseriesx_pre\expandafter
178      {\romannumeral-'0#4}{#1}{#2}{#3}%
179     }%
180   \fi
181 }%
182 \def\XINT_powseriesx_pre #1#2#3#4%
183 {%
184   \XINT_powseries_loop_i {#4}{#3}}{#2}{#3}{#4}{#1}%
185 }%

```

## 40.9 \xintRationalSeries

This computes  $F(a)+\dots+F(b)$  on the basis of the value of  $F(a)$  and the ratios  $F(n)/F(n-1)$ . As in \xintPowerSeries we use an iterative scheme which has the great advantage to avoid denominator build-up. This makes exact computations possible with exponential type series, which would be completely inaccessible to \xintSeries. #1=a, #2=b, #3=F(a), #4=ratio function Modified in 1.06 to give the indices first to a \numexpr rather than expanding twice. I just use \the\numexpr and maintain the previous code after that. 1.08a adds the forgotten optimization following that previous change.

```

186 \def\xintRationalSeries {\romannumeral0\xintratseries }%
187 \def\xintratseries #1#2%
188 {%
189   \expandafter\XINT_ratseries\expandafter
190   {\the\numexpr #1\expandafter}\expandafter{\the\numexpr #2}%
191 }%
192 \def\XINT_ratseries #1#2#3#4%
193 {%
194   \ifnum #2<#1

```

```

195     \xint_afterfi { 0/1[0]}%
196   \else
197     \xint_afterfi
198     {\XINT_ratseries_loop {#2}{1}{#1}{#4}{#3}}%
199   \fi
200}%
201\def\XINT_ratseries_loop #1#2#3#4%
202{%
203   \ifnum #1>#3 \else\XINT_ratseries_exit_i\fi
204   \expandafter\XINT_ratseries_loop\expandafter
205   {\the\numexpr #1-1\expandafter}\expandafter
206   {\romannumeral0\xintadd {1}{\xintMul {#2}{#4{#1}}}}{#3}{#4}%
207}%
208\def\XINT_ratseries_exit_i\fi #1#2#3#4#5#6#7#8%
209{%
210   \fi \XINT_ratseries_exit_ii #6%
211}%
212\def\XINT_ratseries_exit_ii #1#2#3#4#5%
213{%
214   \XINT_ratseries_exit_iii #5%
215}%
216\def\XINT_ratseries_exit_iii #1#2#3#4%
217{%
218   \xintmul{#2}{#4}%
219}%

```

#### 40.10 \xintRationalSeriesX

*a, b, initial, ratiofunction, x*

This computes  $F(a, x) + \dots + F(b, x)$  on the basis of the value of  $F(a, x)$  and the ratios  $F(n, x)/F(n-1, x)$ . The argument  $x$  is first expanded and it is the value resulting from this which is used then throughout. The initial term  $F(a, x)$  must be defined as one-parameter macro which will be given  $x$ . Modified in 1.06 to give the indices first to a `\numexpr` rather than expanding twice. I just use `\the\numexpr` and maintain the previous code after that. 1.08a adds the forgotten optimization following that previous change.

```

220\def\xintRationalSeriesX {\romannumeral0\xintratseriesx}%
221\def\xintratseriesx #1#2%
222{%
223   \expandafter\XINT_ratseriesx\expandafter
224   {\the\numexpr #1\expandafter}\expandafter{\the\numexpr #2}%
225}%
226\def\XINT_ratseriesx #1#2#3#4#5%
227{%
228   \ifnum #2<#1
229     \xint_afterfi { 0/1[0]}%
230   \else
231     \xint_afterfi

```

```

232     {\expandafter\XINT_ratseriesx_pre\expandafter
233       {\romannumeral-‘0#5}{#2}{#1}{#4}{#3}%
234     }%
235   \fi
236 }%
237 \def\XINT_ratseriesx_pre #1#2#3#4#5%
238 {%
239   \XINT_ratseries_loop {#2}{1}{#3}{#4}{#1}}{#5{#1}}%
240 }%

```

#### 40.11 \xintFxFtPowerSeries

I am not too happy with this piece of code. Will make it more economical another day. Modified in 1.06 to give the indices first to a \numexpr rather than expanding twice. I just use \the\numexpr and maintain the previous code after that. 1.08a: forgot last time some optimization from the change to \numexpr.

```

241 \def\xintFxFtPowerSeries {\romannumeral0\xintfxptpowerseries }%
242 \def\xintfxptpowerseries #1#2%
243 {%
244   \expandafter\XINT_fppowseries\expandafter
245   {\the\numexpr #1\expandafter}\expandafter{\the\numexpr #2}%
246 }%
247 \def\XINT_fppowseries #1#2#3#4#5%
248 {%
249   \ifnum #2<#1
250     \xint_afterfi { 0}%
251   \else
252     \xint_afterfi
253     {\expandafter\XINT_fppowseries_loop_pre\expandafter
254       {\romannumeral0\xinttrunc {#5}{\xintPow {#4}{#1}}}%
255       {#1}{#4}{#2}{#3}{#5}%
256     }%
257   \fi
258 }%
259 \def\XINT_fppowseries_loop_pre #1#2#3#4#5#6%
260 {%
261   \ifnum #4>#2 \else\XINT_fppowseries_dont_i \fi
262   \expandafter\XINT_fppowseries_loop_i\expandafter
263   {\the\numexpr #2+\xint_c_i\expandafter}\expandafter
264   {\romannumeral0\xintitrunc {#6}{\xintMul {#5{#2}}{#1}}}%
265   {#1}{#3}{#4}{#5}{#6}%
266 }%
267 \def\XINT_fppowseries_dont_i \fi\expandafter\XINT_fppowseries_loop_i
268   {\fi \expandafter\XINT_fppowseries_dont_ii }%
269 \def\XINT_fppowseries_dont_ii #1#2#3#4#5#6#7{\xinttrunc {#7}{#2[-#7]}}%
270 \def\XINT_fppowseries_loop_i #1#2#3#4#5#6#7%
271 {%
272   \ifnum #5>#1 \else \XINT_fppowseries_exit_i \fi

```

```

273 \expandafter\XINT_fppowseries_loop_ii\expandafter
274 {\romannumeral0\xinttrunc {#7}{\xintMul {#3}{#4}}}%
275 {#1}{#4}{#2}{#5}{#6}{#7}%
276 }%
277 \def\XINT_fppowseries_loop_ii #1#2#3#4#5#6#7%
278 {%
279 \expandafter\XINT_fppowseries_loop_i\expandafter
280 {\the\numexpr #2+\xint_c_i\expandafter}\expandafter
281 {\romannumeral0\xintiiadd {#4}{\xintiTrunc {#7}{\xintMul {#6{#2}}{#1}}}}%
282 {#1}{#3}{#5}{#6}{#7}%
283 }%
284 \def\XINT_fppowseries_exit_i\fi\expandafter\XINT_fppowseries_loop_ii
285 {\fi \expandafter\XINT_fppowseries_exit_ii }%
286 \def\XINT_fppowseries_exit_ii #1#2#3#4#5#6#7%
287 {%
288 \xinttrunc {#7}
289 {\xintiiadd {#4}{\xintiTrunc {#7}{\xintMul {#6{#2}}{#1}}}{-#7}}%
290 }%

```

#### 40.12 \xintFxFtPowerSeriesX

a,b,coeff,x,D

Modified in 1.06 to give the indices first to a \numexpr rather than expanding twice. I just use \the\numexpr and maintain the previous code after that. 1.08a adds the forgotten optimization following that previous change.

```

291 \def\xintFxFtPowerSeriesX {\romannumeral0\xintfxptpowerseriesx }%
292 \def\xintfxptpowerseriesx #1#2%
293 {%
294 \expandafter\XINT_fppowseriesx\expandafter
295 {\the\numexpr #1\expandafter}\expandafter{\the\numexpr #2}%
296 }%
297 \def\XINT_fppowseriesx #1#2#3#4#5%
298 {%
299 \ifnum #2<#1
300 \xint_afterfi { 0}%
301 \else
302 \xint_afterfi
303 {\expandafter \XINT_fppowseriesx_pre \expandafter
304 {\romannumeral- '0#4}{#1}{#2}{#3}{#5}%
305 }%
306 \fi
307 }%
308 \def\XINT_fppowseriesx_pre #1#2#3#4#5%
309 {%
310 \expandafter\XINT_fppowseries_loop_pre\expandafter
311 {\romannumeral0\xinttrunc {#5}{\xintPow {#1}{#2}}}%
312 {#2}{#1}{#3}{#4}{#5}%
313 }%

```

**40.13 \xintFloatPowerSeries**

1.08a. I still have to re-visit \xintFxpTPowerSeries; temporarily I just adapted the code to the case of floats.

```

314 \def\xintFloatPowerSeries {\romannumeral0\xintfloatpowerseries }%
315 \def\xintfloatpowerseries #1{\XINT_flpowseries_chkopt #1\Z }%
316 \def\XINT_flpowseries_chkopt #1%
317 {%
318   \ifx [#1\expandafter\XINT_flpowseries_opt
319     \else\expandafter\XINT_flpowseries_noopt
320   \fi
321   #1%
322 }%
323 \def\XINT_flpowseries_noopt #1\Z #2%
324 {%
325   \expandafter\XINT_flpowseries\expandafter
326   {\the\numexpr #1\expandafter}\expandafter
327   {\the\numexpr #2}\XINTdigits
328 }%
329 \def\XINT_flpowseries_opt [\Z #1]#2#3%
330 {%
331   \expandafter\XINT_flpowseries\expandafter
332   {\the\numexpr #2\expandafter}\expandafter
333   {\the\numexpr #3\expandafter}{\the\numexpr #1}%
334 }%
335 \def\XINT_flpowseries #1#2#3#4#5%
336 {%
337   \ifnum #2<#1
338     \xint_afterfi { 0.e0}%
339   \else
340     \xint_afterfi
341     {\expandafter\XINT_flpowseries_loop_pre\expandafter
342      {\romannumeral0\XINTinfloatpow [#3]{#5}{#1}}%
343      {#1}{#5}{#2}{#4}{#3}%
344     }%
345   \fi
346 }%
347 \def\XINT_flpowseries_loop_pre #1#2#3#4#5#6%
348 {%
349   \ifnum #4>#2 \else\XINT_flpowseries_dont_i \fi
350   \expandafter\XINT_flpowseries_loop_i\expandafter
351   {\the\numexpr #2+\xint_c_i\expandafter}\expandafter
352   {\romannumeral0\XINTinfloatmul [#6]{#5{#2}}{#1}}%
353   {#1}{#3}{#4}{#5}{#6}%
354 }%
355 \def\XINT_flpowseries_dont_i \fi\expandafter\XINT_flpowseries_loop_i
356   {\fi \expandafter\XINT_flpowseries_dont_ii }%
357 \def\XINT_flpowseries_dont_ii #1#2#3#4#5#6#7{\xintfloat [#7]{#2}}%

```

```

358 \def\XINT_flpowseries_loop_i #1#2#3#4#5#6#7%
359 {%
360   \ifnum #5>#1 \else \XINT_flpowseries_exit_i \fi
361   \expandafter\XINT_flpowseries_loop_ii\expandafter
362   {\romannumeral0\XINTinfloatmul [#7]{#3}{#4}}%
363   {#1}{#4}{#2}{#5}{#6}{#7}%
364 }%
365 \def\XINT_flpowseries_loop_ii #1#2#3#4#5#6#7%
366 {%
367   \expandafter\XINT_flpowseries_loop_i\expandafter
368   {\the\numexpr #2+\xint_c_i\expandafter}\expandafter
369   {\romannumeral0\XINTinfloatadd [#7]{#4}%
370    {\XINTinfloatmul [#7]{#6{#2}}{#1}}}%
371   {#1}{#3}{#5}{#6}{#7}%
372 }%
373 \def\XINT_flpowseries_exit_i\fi\expandafter\XINT_flpowseries_loop_ii
374   {\fi \expandafter\XINT_flpowseries_exit_ii }%
375 \def\XINT_flpowseries_exit_ii #1#2#3#4#5#6#7%
376 {%
377   \xintfloatadd [#7]{#4}{\XINTinfloatmul [#7]{#6{#2}}{#1}}%
378 }%

```

#### 40.14 \xintFloatPowerSeriesX

1.08a

```

379 \def\xintFloatPowerSeriesX {\romannumeral0\xintfloatpowerseriesx }%
380 \def\xintfloatpowerseriesx #1{\XINT_flpowseriesx_chkopt #1\Z }%
381 \def\XINT_flpowseriesx_chkopt #1%
382 {%
383   \ifx [#1\expandafter\XINT_flpowseriesx_opt
384     \else\expandafter\XINT_flpowseriesx_noopt
385   \fi
386   #1%
387 }%
388 \def\XINT_flpowseriesx_noopt #1\Z #2%
389 {%
390   \expandafter\XINT_flpowseriesx\expandafter
391   {\the\numexpr #1\expandafter}\expandafter
392   {\the\numexpr #2}\XINTdigits
393 }%
394 \def\XINT_flpowseriesx_opt [\Z #1]#2#3%
395 {%
396   \expandafter\XINT_flpowseriesx\expandafter
397   {\the\numexpr #2\expandafter}\expandafter
398   {\the\numexpr #3\expandafter}{\the\numexpr #1}%
399 }%
400 \def\XINT_flpowseriesx #1#2#3#4#5%
401 {%

```

```

402 \ifnum #2<#1
403   \xint_afterfi { 0.e0}%
404 \else
405   \xint_afterfi
406     {\expandafter \XINT_flpowseriesx_pre \expandafter
407       {\romannumeral-‘0#5}{#1}{#2}{#4}{#3}%
408       }%
409   \fi
410 }%
411 \def\XINT_flpowseriesx_pre #1#2#3#4#5%
412 {%
413   \expandafter\XINT_flpowseries_loop_pre\expandafter
414     {\romannumeral0\XINTinfloatpow [#5]{#1}{#2}}%
415     {#2}{#1}{#3}{#4}{#5}%
416 }%
417 \XINT_restorecatcodes_endinput%

```

## 41 Package **xintcfrac** implementation

The commenting is currently (2014/01/09) very sparse.

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### 41.1 Catcodes, $\varepsilon$ -TeX and reload detection

The code for reload detection is copied from HEIKO OBERDIEK’s packages, and adapted here to check for previous loading of the **xintfrac** package.

The method for catcodes is slightly different, but still directly inspired by these packages.

```
1 \begingroup\catcode61\catcode48\catcode32=10\relax%
```

```

2 \catcode13=5 % ^^M
3 \endlinechar=13 %
4 \catcode123=1 % {
5 \catcode125=2 % }
6 \catcode64=11 % @
7 \catcode35=6 % #
8 \catcode44=12 % ,
9 \catcode45=12 % -
10 \catcode46=12 % .
11 \catcode58=12 % :
12 \def\space { }%
13 \let\z\endgroup
14 \expandafter\let\expandafter\x\csname ver@xintcfrac.sty\endcsname
15 \expandafter\let\expandafter\w\csname ver@xintfrac.sty\endcsname
16 \expandafter
17 \ifx\csname PackageInfo\endcsname\relax
18 \def\y#1#2{\immediate\write-1{Package #1 Info: #2.}}%
19 \else
20 \def\y#1#2{\PackageInfo{#1}{#2}}%
21 \fi
22 \expandafter
23 \ifx\csname numexpr\endcsname\relax
24 \y{xintcfrac}{\numexpr not available, aborting input}%
25 \aftergroup\endinput
26 \else
27 \ifx\x\relax % plain-TeX, first loading of xintcfrac.sty
28 \ifx\w\relax % but xintfrac.sty not yet loaded.
29 \y{xintcfrac}{now issuing \string\input\space xintfrac.sty}%
30 \def\z{\endgroup\input xintfrac.sty\relax}%
31 \fi
32 \else
33 \def\empty {}%
34 \ifx\x\empty % LaTeX, first loading,
35 % variable is initialized, but \ProvidesPackage not yet seen
36 \ifx\w\relax % xintfrac.sty not yet loaded.
37 \y{xintcfrac}{now issuing \string\RequirePackage{xintfrac}}%
38 \def\z{\endgroup\RequirePackage{xintfrac}}%
39 \fi
40 \else
41 \y{xintcfrac}{I was already loaded, aborting input}%
42 \aftergroup\endinput
43 \fi
44 \fi
45 \fi
46 \z%

```

## 41.2 Confirmation of *xintfrac* loading

```
47 \begingroup\catcode61\catcode48\catcode32=10\relax%
```

## 41 Package *xintcfrac* implementation

```
48 \catcode13=5      % ^^M
49 \endlinechar=13 %
50 \catcode123=1     % {
51 \catcode125=2     % }
52 \catcode64=11     % @
53 \catcode35=6      % #
54 \catcode44=12     % ,
55 \catcode45=12     % -
56 \catcode46=12     % .
57 \catcode58=12     % :
58 \ifdefined\PackageInfo
59   \def\y#1#2{\PackageInfo{#1}{#2}}%
60   \else
61     \def\y#1#2{\immediate\write-1{Package #1 Info: #2.}}%
62   \fi
63 \def\empty {}%
64 \expandafter\let\expandafter\w\csname ver@xintfrac.sty\endcsname
65 \ifx\w\relax % Plain TeX, user gave a file name at the prompt
66   \y{xintcfrac}{Loading of package xintfrac failed, aborting input}%
67   \aftergroup\endinput
68 \fi
69 \ifx\w\empty % LaTeX, user gave a file name at the prompt
70   \y{xintcfrac}{Loading of package xintfrac failed, aborting input}%
71   \aftergroup\endinput
72 \fi
73 \endgroup%
```

### 41.3 Catcodes

```
74 \XINTsetupcatcodes%
```

### 41.4 Package identification

```
75 \XINT_providespackage
76 \ProvidesPackage{xintcfrac}%
77 [2014/01/09 v1.09j Expandable continued fractions with xint package (jfb)]%
```

### 41.5 \xintCFrac

```
78 \def\xintCFrac {\romannumeral0\xintcfrac}%
79 \def\xintcfrac #1%
80 {%
81   \XINT_cfrac_opt_a #1\Z
82 }%
83 \def\XINT_cfrac_opt_a #1%
84 {%
85   \ifx[#1\XINT_cfrac_opt_b\fi \XINT_cfrac_noopt #1%
86 }%
87 \def\XINT_cfrac_noopt #1\Z
88 {%
89   \expandafter\XINT_cfrac_A\romannumeral0\xintraewithzeros {#1}\Z
```

```

90   \relax\relax
91 }%
92 \def\XINT_cfrac_opt_b\fi\XINT_cfrac_noopt [\Z #1]%
93 {%
94   \fi\csname XINT_cfrac_opt#1\endcsname
95 }%
96 \def\XINT_cfrac_optl #1%
97 {%
98   \expandafter\XINT_cfrac_A\romannumeral0\xintraewithzeros {#1}\Z
99   \relax\hfill
100}%
101 \def\XINT_cfrac_optc #1%
102 {%
103   \expandafter\XINT_cfrac_A\romannumeral0\xintraewithzeros {#1}\Z
104   \relax\relax
105}%
106 \def\XINT_cfrac_optr #1%
107 {%
108   \expandafter\XINT_cfrac_A\romannumeral0\xintraewithzeros {#1}\Z
109   \hfill\relax
110}%
111 \def\XINT_cfrac_A #1/#2\Z
112 {%
113   \expandafter\XINT_cfrac_B\romannumeral0\xintiidivision {#1}{#2}{#2}%
114}%
115 \def\XINT_cfrac_B #1#2%
116 {%
117   \XINT_cfrac_C #2\Z {#1}%
118}%
119 \def\XINT_cfrac_C #1%
120 {%
121   \xint_gob_til_zero #1\XINT_cfrac_integer 0\XINT_cfrac_D #1%
122}%
123 \def\XINT_cfrac_integer 0\XINT_cfrac_D 0#1\Z #2#3#4#5{ #2}%
124 \def\XINT_cfrac_D #1\Z #2#3{\XINT_cfrac_loop_a {#1}{#3}{#1}{{#2}}}%
125 \def\XINT_cfrac_loop_a
126 {%
127   \expandafter\XINT_cfrac_loop_d\romannumeral0\XINT_div_prepare
128}%
129 \def\XINT_cfrac_loop_d #1#2%
130 {%
131   \XINT_cfrac_loop_e #2.{#1}%
132}%
133 \def\XINT_cfrac_loop_e #1%
134 {%
135   \xint_gob_til_zero #1\xint_cfrac_loop_exit0\XINT_cfrac_loop_f #1%
136}%
137 \def\XINT_cfrac_loop_f #1.#2#3#4%
138 {%

```

```

139   \XINT_cfrac_loop_a {#1}{#3}{#1}{{#2}#4}%
140 }%
141 \def\xint_cfrac_loop_exit0\XINT_cfrac_loop_f #1.#2#3#4#5#6%
142   {\XINT_cfrac_T #5#6{#2}#4\Z }%
143 \def\XINT_cfrac_T #1#2#3#4%
144 {%
145   \xint_gob_til_Z #4\XINT_cfrac_end\Z\XINT_cfrac_T #1#2{#4+\cfrac{#1#2}{#3}}%
146 }%
147 \def\XINT_cfrac_end\Z\XINT_cfrac_T #1#2#3%
148 {%
149   \XINT_cfrac_end_b #3%
150 }%
151 \def\XINT_cfrac_end_b \Z+\cfrac#1#2{ #2}%

```

#### 41.6 \xintGCFrac

```

152 \def\xintGCFrac {\romannumeral0\xintgcfrac }%
153 \def\xintgcfrac #1{\XINT_gcfrac_opt_a #1\Z }%
154 \def\XINT_gcfrac_opt_a #1%
155 {%
156   \ifx[#1\XINT_gcfrac_opt_b\fi \XINT_gcfrac_noopt #1%
157 }%
158 \def\XINT_gcfrac_noopt #1\Z
159 {%
160   \XINT_gcfrac #1+\W/\relax\relax
161 }%
162 \def\XINT_gcfrac_opt_b\fi\XINT_gcfrac_noopt [\Z #1]%
163 {%
164   \fi\csname XINT_gcfrac_opt#1\endcsname
165 }%
166 \def\XINT_gcfrac_optl #1%
167 {%
168   \XINT_gcfrac #1+\W/\relax\hfill
169 }%
170 \def\XINT_gcfrac_optc #1%
171 {%
172   \XINT_gcfrac #1+\W/\relax\relax
173 }%
174 \def\XINT_gcfrac_optr #1%
175 {%
176   \XINT_gcfrac #1+\W/\hfill\relax
177 }%
178 \def\XINT_gcfrac
179 {%
180   \expandafter\XINT_gcfrac_enter\romannumeral-‘0%
181 }%
182 \def\XINT_gcfrac_enter {\XINT_gcfrac_loop {}}%
183 \def\XINT_gcfrac_loop #1#2+#3/%
184 {%
185   \xint_gob_til_W #3\XINT_gcfrac_endloop\W

```

#### 41 Package *xintcfrac* implementation

```

186 \XINT_gcfrac_loop {{{#3}{#2}#1}%
187 }%
188 \def\XINT_gcfrac_endloop\W\XINT_gcfrac_loop #1#2#3%
189 {%
190 \XINT_gcfrac_T #2#3#1\Z\Z
191 }%
192 \def\XINT_gcfrac_T #1#2#3#4{\XINT_gcfrac_U #1#2{\xintFrac{#4}}}%
193 \def\XINT_gcfrac_U #1#2#3#4#5%
194 {%
195 \xint_gob_til_Z #5\XINT_gcfrac_end\Z\XINT_gcfrac_U
196 #1#2{\xintFrac{#5}%
197 \ifcase\xintSgn{#4}
198 +\or+\else-\fi
199 \cfrac{#1\xintFrac{\xintAbs{#4}}#2}{#3}}%
200 }%
201 \def\XINT_gcfrac_end\Z\XINT_gcfrac_U #1#2#3%
202 {%
203 \XINT_gcfrac_end_b #3%
204 }%
205 \def\XINT_gcfrac_end_b #1\cfrac#2#3{ #3}%

```

##### 41.7 \xintGctoGCx

```

206 \def\xintGctoGCx {\romannumeral0\xintgctogcx }%
207 \def\xintgctogcx #1#2#3%
208 {%
209 \expandafter\XINT_gctgcx_start\expandafter {\romannumeral-‘0#3}{#1}{#2}%
210 }%
211 \def\XINT_gctgcx_start #1#2#3{\XINT_gctgcx_loop_a }{{#2}{#3}#1+\W/}%
212 \def\XINT_gctgcx_loop_a #1#2#3#4+#5/%
213 {%
214 \xint_gob_til_W #5\XINT_gctgcx_end\W
215 \XINT_gctgcx_loop_b {#1{#4}}{#2{#5}#3}{#2}{#3}%
216 }%
217 \def\XINT_gctgcx_loop_b #1#2%
218 {%
219 \XINT_gctgcx_loop_a {#1#2}%
220 }%
221 \def\XINT_gctgcx_end\W\XINT_gctgcx_loop_b #1#2#3#4{ #1}%

```

##### 41.8 \xintFtoCs

```

222 \def\xintFtoCs {\romannumeral0\xintftocs }%
223 \def\xintftocs #1%
224 {%
225 \expandafter\XINT_ftc_A\romannumeral0\xintrawwithzeros {#1}\Z
226 }%
227 \def\XINT_ftc_A #1/#2\Z
228 {%
229 \expandafter\XINT_ftc_B\romannumeral0\xintiidivision {#1}{#2}{#2}%
230 }%

```

```

231 \def\XINT_ftc_B #1#2%
232 {%
233   \XINT_ftc_C #2.{#1}%
234 }%
235 \def\XINT_ftc_C #1%
236 {%
237   \xint_gob_til_zero #1\XINT_ftc_integer 0\XINT_ftc_D #1%
238 }%
239 \def\XINT_ftc_integer 0\XINT_ftc_D 0#1.#2#3{ #2}%
240 \def\XINT_ftc_D #1.#2#3{\XINT_ftc_loop_a {#1}{#3}{#1}{#2},}%
241 \def\XINT_ftc_loop_a
242 {%
243   \expandafter\XINT_ftc_loop_d\romannumeral0\XINT_div_prepare
244 }%
245 \def\XINT_ftc_loop_d #1#2%
246 {%
247   \XINT_ftc_loop_e #2.{#1}%
248 }%
249 \def\XINT_ftc_loop_e #1%
250 {%
251   \xint_gob_til_zero #1\xint_ftc_loop_exit0\XINT_ftc_loop_f #1%
252 }%
253 \def\XINT_ftc_loop_f #1.#2#3#4%
254 {%
255   \XINT_ftc_loop_a {#1}{#3}{#1}{#4#2},}%
256 }%
257 \def\xint_ftc_loop_exit0\XINT_ftc_loop_f #1.#2#3#4{ #4#2}%

```

#### 41.9 \xintFtoCx

```

258 \def\xintFtoCx {\romannumeral0\xintftocx }%
259 \def\xintftocx #1#2%
260 {%
261   \expandafter\XINT_ftcx_A\romannumeral0\xintrawwithzeros {#2}\Z {#1}%
262 }%
263 \def\XINT_ftcx_A #1/#2\Z
264 {%
265   \expandafter\XINT_ftcx_B\romannumeral0\xintiidivision {#1}{#2}{#2}%
266 }%
267 \def\XINT_ftcx_B #1#2%
268 {%
269   \XINT_ftcx_C #2.{#1}%
270 }%
271 \def\XINT_ftcx_C #1%
272 {%
273   \xint_gob_til_zero #1\XINT_ftcx_integer 0\XINT_ftcx_D #1%
274 }%
275 \def\XINT_ftcx_integer 0\XINT_ftcx_D 0#1.#2#3#4{ #2}%
276 \def\XINT_ftcx_D #1.#2#3#4{\XINT_ftcx_loop_a {#1}{#3}{#1}{#2#4}{#4}}%
277 \def\XINT_ftcx_loop_a

```

```

278 {%
279   \expandafter\XINT_ftcx_loop_d\romannumeral0\XINT_div_prepare
280 }%
281 \def\XINT_ftcx_loop_d #1#2%
282 {%
283   \XINT_ftcx_loop_e #2.{#1}%
284 }%
285 \def\XINT_ftcx_loop_e #1%
286 {%
287   \xint_gob_til_zero #1\xint_ftcx_loop_exit0\XINT_ftcx_loop_f #1%
288 }%
289 \def\XINT_ftcx_loop_f #1.#2#3#4#5%
290 {%
291   \XINT_ftcx_loop_a {#1}{#3}{#1}{#4}{#2}{#5}{#5}%
292 }%
293 \def\xint_ftcx_loop_exit0\XINT_ftcx_loop_f #1.#2#3#4#5{ #4{#2}}%

```

#### 41.10 \xintFtoGC

```

294 \def\xintFtoGC {\romannumeral0\xintftogc }%
295 \def\xintftogc {\xintftocx {+1/}}%

```

#### 41.11 \xintFtoCC

```

296 \def\xintFtoCC {\romannumeral0\xintftocc }%
297 \def\xintftocc #1%
298 {%
299   \expandafter\XINT_ftcc_A\expandafter {\romannumeral0\xintrawwithzeros {#1}}%
300 }%
301 \def\XINT_ftcc_A #1%
302 {%
303   \expandafter\XINT_ftcc_B
304   \romannumeral0\xintrawwithzeros {\xintAdd {1/2[0]}{#1[0]}}\Z {#1[0]}%
305 }%
306 \def\XINT_ftcc_B #1/#2\Z
307 {%
308   \expandafter\XINT_ftcc_C\expandafter {\romannumeral0\xintiiquo {#1}{#2}}%
309 }%
310 \def\XINT_ftcc_C #1#2%
311 {%
312   \expandafter\XINT_ftcc_D\romannumeral0\xintsub {#2}{#1}\Z {#1}%
313 }%
314 \def\XINT_ftcc_D #1%
315 {%
316   \xint_UDzerominusfork
317   #1-\XINT_ftcc_integer
318   0#1\XINT_ftcc_En
319   0-\XINT_ftcc_Ep #1}%
320 \krof
321 }%
322 \def\XINT_ftcc_Ep #1\Z #2%

```

```

323 {%
324   \expandafter\XINT_ftcc_loop_a\expandafter
325   {\romannumeral0\xintdiv {1[0]}\{#1}\{#2+1/}%
326 }%
327 \def\XINT_ftcc_En #1\Z #2%
328 {%
329   \expandafter\XINT_ftcc_loop_a\expandafter
330   {\romannumeral0\xintdiv {1[0]}\{#1}\{#2+-1/}%
331 }%
332 \def\XINT_ftcc_integer #1\Z #2{ #2}%
333 \def\XINT_ftcc_loop_a #1%
334 {%
335   \expandafter\XINT_ftcc_loop_b
336   \romannumeral0\xintrawithzeros {\xintAdd {1/2[0]}\{#1}\Z {#1}%
337 }%
338 \def\XINT_ftcc_loop_b #1/#2\Z
339 {%
340   \expandafter\XINT_ftcc_loop_c\expandafter
341   {\romannumeral0\xintiigo {#1}\{#2}%
342 }%
343 \def\XINT_ftcc_loop_c #1#2%
344 {%
345   \expandafter\XINT_ftcc_loop_d
346   \romannumeral0\xintsub {#2}\{#1[0]}\Z {#1}%
347 }%
348 \def\XINT_ftcc_loop_d #1%
349 {%
350   \xint_UDzerominusfork
351   #1-\XINT_ftcc_end
352   0#1\XINT_ftcc_loop_N
353   0-\XINT_ftcc_loop_P #1}%
354   \krof
355 }%
356 \def\XINT_ftcc_end #1\Z #2#3{ #3#2}%
357 \def\XINT_ftcc_loop_P #1\Z #2#3%
358 {%
359   \expandafter\XINT_ftcc_loop_a\expandafter
360   {\romannumeral0\xintdiv {1[0]}\{#1}\{#3#2+1/}%
361 }%
362 \def\XINT_ftcc_loop_N #1\Z #2#3%
363 {%
364   \expandafter\XINT_ftcc_loop_a\expandafter
365   {\romannumeral0\xintdiv {1[0]}\{#1}\{#3#2+-1/}%
366 }%

```

#### 41.12 \xintFtoCv

```

367 \def\xintFtoCv {\romannumeral0\xintftocv }%
368 \def\xintftocv #1%
369 {%

```

```

370 \xinticstocv {\xintFtoCs {#1}}%
371 }%

```

#### 41.13 \xintFtoCCv

```

372 \def\xintFtoCCv {\romannumeral0\xintftoccv }%
373 \def\xintftoccv #1%
374 {%
375 \xintigctocv {\xintFtoCC {#1}}%
376 }%

```

#### 41.14 \xintCstoF

```

377 \def\xintCstoF {\romannumeral0\xintcstof }%
378 \def\xintcstof #1%
379 {%
380 \expandafter\xINT_cstf_prep \romannumeral-‘0#1,\W,%
381 }%
382 \def\xINT_cstf_prep
383 {%
384 \XINT_cstf_loop_a 1001%
385 }%
386 \def\xINT_cstf_loop_a #1#2#3#4#5,%
387 {%
388 \xint_gob_til_W #5\xINT_cstf_end\W
389 \expandafter\xINT_cstf_loop_b
390 \romannumeral0\xintraewithzeros {#5}#{#1}#{#2}#{#3}#{#4}%
391 }%
392 \def\xINT_cstf_loop_b #1/#2.#3#4#5#6%
393 {%
394 \expandafter\xINT_cstf_loop_c\expandafter
395 {\romannumeral0\xINT_mul_fork #2\Z #4\Z }%
396 {\romannumeral0\xINT_mul_fork #2\Z #3\Z }%
397 {\romannumeral0\xintiiadd {\XINT_Mul {#2}#{#6}}{\XINT_Mul {#1}#{#4}}}%
398 {\romannumeral0\xintiiadd {\XINT_Mul {#2}#{#5}}{\XINT_Mul {#1}#{#3}}}%
399 }%
400 \def\xINT_cstf_loop_c #1#2%
401 {%
402 \expandafter\xINT_cstf_loop_d\expandafter {\expandafter{#2}#{#1}}%
403 }%
404 \def\xINT_cstf_loop_d #1#2%
405 {%
406 \expandafter\xINT_cstf_loop_e\expandafter {\expandafter{#2}#1}%
407 }%
408 \def\xINT_cstf_loop_e #1#2%
409 {%
410 \expandafter\xINT_cstf_loop_a\expandafter{#2}#1%
411 }%
412 \def\xINT_cstf_end #1.#2#3#4#5{\xintraewithzeros {#2/#3}}% 1.09b removes [0]

```

**41.15 \xintiCstoF**

```

413 \def\xintiCstoF {\romannumeral0\xinticstof }%
414 \def\xinticstof #1%
415 {%
416   \expandafter\XINT_icstf_prep \romannumeral-‘0#1,\W,%
417 }%
418 \def\XINT_icstf_prep
419 {%
420   \XINT_icstf_loop_a 1001%
421 }%
422 \def\XINT_icstf_loop_a #1#2#3#4#5,%
423 {%
424   \xint_gob_til_W #5\XINT_icstf_end\W
425   \expandafter
426   \XINT_icstf_loop_b \romannumeral-‘0#5.{#1}{#2}{#3}{#4}%
427 }%
428 \def\XINT_icstf_loop_b #1.#2#3#4#5%
429 {%
430   \expandafter\XINT_icstf_loop_c\expandafter
431   {\romannumeral0\xintiiadd {#5}{\XINT_Mul {#1}{#3}}}%
432   {\romannumeral0\xintiiadd {#4}{\XINT_Mul {#1}{#2}}}%
433   {#2}{#3}%
434 }%
435 \def\XINT_icstf_loop_c #1#2%
436 {%
437   \expandafter\XINT_icstf_loop_a\expandafter {#2}{#1}%
438 }%
439 \def\XINT_icstf_end#1.#2#3#4#5{\xintrawithzeros {#2/#3}}% 1.09b removes [0]

```

**41.16 \xintGctoF**

```

440 \def\xintGctoF {\romannumeral0\xintgctof }%
441 \def\xintgctof #1%
442 {%
443   \expandafter\XINT_gctf_prep \romannumeral-‘0#1+\W/%
444 }%
445 \def\XINT_gctf_prep
446 {%
447   \XINT_gctf_loop_a 1001%
448 }%
449 \def\XINT_gctf_loop_a #1#2#3#4#5+%
450 {%
451   \expandafter\XINT_gctf_loop_b
452   \romannumeral0\xintrawithzeros {#5}.{#1}{#2}{#3}{#4}%
453 }%
454 \def\XINT_gctf_loop_b #1/#2.#3#4#5#6%
455 {%
456   \expandafter\XINT_gctf_loop_c\expandafter
457   {\romannumeral0\XINT_mul_fork #2\Z #4\Z }%

```

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```

458 {\romannumeral0\XINT_mul_fork #2\Z #3\Z }%
459 {\romannumeral0\xintiiadd {\XINT_Mul {#2}{#6}}{\XINT_Mul {#1}{#4}}}%
460 {\romannumeral0\xintiiadd {\XINT_Mul {#2}{#5}}{\XINT_Mul {#1}{#3}}}%
461 }%
462 \def\XINT_gctf_loop_c #1#2%
463 {%
464 \expandafter\XINT_gctf_loop_d\expandafter {\expandafter{#2}{#1}}%
465 }%
466 \def\XINT_gctf_loop_d #1#2%
467 {%
468 \expandafter\XINT_gctf_loop_e\expandafter {\expandafter{#2}{#1}}%
469 }%
470 \def\XINT_gctf_loop_e #1#2%
471 {%
472 \expandafter\XINT_gctf_loop_f\expandafter {\expandafter{#2}{#1}}%
473 }%
474 \def\XINT_gctf_loop_f #1#2/%
475 {%
476 \xint_gob_til_W #2\XINT_gctf_end\W
477 \expandafter\XINT_gctf_loop_g
478 \romannumeral0\xintraewithzeros {#2}.#1%
479 }%
480 \def\XINT_gctf_loop_g #1/#2.#3#4#5#6%
481 {%
482 \expandafter\XINT_gctf_loop_h\expandafter
483 {\romannumeral0\XINT_mul_fork #1\Z #6\Z }%
484 {\romannumeral0\XINT_mul_fork #1\Z #5\Z }%
485 {\romannumeral0\XINT_mul_fork #2\Z #4\Z }%
486 {\romannumeral0\XINT_mul_fork #2\Z #3\Z }%
487 }%
488 \def\XINT_gctf_loop_h #1#2%
489 {%
490 \expandafter\XINT_gctf_loop_i\expandafter {\expandafter{#2}{#1}}%
491 }%
492 \def\XINT_gctf_loop_i #1#2%
493 {%
494 \expandafter\XINT_gctf_loop_j\expandafter {\expandafter{#2}{#1}}%
495 }%
496 \def\XINT_gctf_loop_j #1#2%
497 {%
498 \expandafter\XINT_gctf_loop_a\expandafter {#2}{#1}%
499 }%
500 \def\XINT_gctf_end #1.#2#3#4#5{\xintraewithzeros {#2/#3}}% 1.09b removes [0]

```

##### 41.17 \xintiGctoF

```

501 \def\xintiGctoF {\romannumeral0\xintigctof }%
502 \def\xintigctof #1%
503 {%
504 \expandafter\XINT_igctf_prep \romannumeral-‘0#1+\W/%

```

```

505 }%
506 \def\XINT_igctf_prep
507 {%
508   \XINT_igctf_loop_a 1001%
509 }%
510 \def\XINT_igctf_loop_a #1#2#3#4#5+%
511 {%
512   \expandafter\XINT_igctf_loop_b
513   \romannumeral-'0#5.{#1}{#2}{#3}{#4}%
514 }%
515 \def\XINT_igctf_loop_b #1.#2#3#4#5%
516 {%
517   \expandafter\XINT_igctf_loop_c\expandafter
518   {\romannumeral0\xintiiadd {#5}{\XINT_Mul {#1}{#3}}}%
519   {\romannumeral0\xintiiadd {#4}{\XINT_Mul {#1}{#2}}}%
520   {#2}{#3}%
521 }%
522 \def\XINT_igctf_loop_c #1#2%
523 {%
524   \expandafter\XINT_igctf_loop_f\expandafter {\expandafter{#2}{#1}}%
525 }%
526 \def\XINT_igctf_loop_f #1#2#3#4/%
527 {%
528   \xint_gob_til_W #4\XINT_igctf_end\W
529   \expandafter\XINT_igctf_loop_g
530   \romannumeral-'0#4.{#2}{#3}#1%
531 }%
532 \def\XINT_igctf_loop_g #1.#2#3%
533 {%
534   \expandafter\XINT_igctf_loop_h\expandafter
535   {\romannumeral0\XINT_mul_fork #1\Z #3\Z }%
536   {\romannumeral0\XINT_mul_fork #1\Z #2\Z }%
537 }%
538 \def\XINT_igctf_loop_h #1#2%
539 {%
540   \expandafter\XINT_igctf_loop_i\expandafter {#2}{#1}%
541 }%
542 \def\XINT_igctf_loop_i #1#2#3#4%
543 {%
544   \XINT_igctf_loop_a {#3}{#4}{#1}{#2}%
545 }%
546 \def\XINT_igctf_end #1.#2#3#4#5{\xintrawithzeros {#4/#5}}% 1.09b removes [0]

```

#### 41.18 \xintCstoCv

```

547 \def\xintCstoCv {\romannumeral0\xintcstocv }%
548 \def\xintcstocv #1%
549 {%
550   \expandafter\XINT_cstcv_prep \romannumeral-'0#1,\W,%
551 }%

```

```

552 \def\XINT_cstcv_prep
553 {%
554   \XINT_cstcv_loop_a {}1001%
555 }%
556 \def\XINT_cstcv_loop_a #1#2#3#4#5#6,%
557 {%
558   \xint_gob_til_W #6\XINT_cstcv_end\W
559   \expandafter\XINT_cstcv_loop_b
560   \romannumeral0\xintrawithzeros {#6}#{2}#{3}#{4}#{5}#{1}%
561 }%
562 \def\XINT_cstcv_loop_b #1/#2.#3#4#5#6%
563 {%
564   \expandafter\XINT_cstcv_loop_c\expandafter
565   {\romannumeral0\XINT_mul_fork #2\Z #4\Z }%
566   {\romannumeral0\XINT_mul_fork #2\Z #3\Z }%
567   {\romannumeral0\xintiiadd {\XINT_Mul {#2}#{6}}{\XINT_Mul {#1}#{4}}}%
568   {\romannumeral0\xintiiadd {\XINT_Mul {#2}#{5}}{\XINT_Mul {#1}#{3}}}%
569 }%
570 \def\XINT_cstcv_loop_c #1#2%
571 {%
572   \expandafter\XINT_cstcv_loop_d\expandafter {\expandafter{#2}#{1}}%
573 }%
574 \def\XINT_cstcv_loop_d #1#2%
575 {%
576   \expandafter\XINT_cstcv_loop_e\expandafter {\expandafter{#2}#1}%
577 }%
578 \def\XINT_cstcv_loop_e #1#2%
579 {%
580   \expandafter\XINT_cstcv_loop_f\expandafter{#2}#1%
581 }%
582 \def\XINT_cstcv_loop_f #1#2#3#4#5%
583 {%
584   \expandafter\XINT_cstcv_loop_g\expandafter
585   {\romannumeral0\xintrawithzeros {#1/#2}#{5}#{1}#{2}#{3}#{4}%
586 }%
587 \def\XINT_cstcv_loop_g #1#2{\XINT_cstcv_loop_a {#2}#{1}}% 1.09b removes [0]
588 \def\XINT_cstcv_end #1.#2#3#4#5#6{ #6}%

```

#### 41.19 \xintiCstoCv

```

589 \def\xintiCstoCv {\romannumeral0\xinticstocv }%
590 \def\xinticstocv #1%
591 {%
592   \expandafter\XINT_icstcv_prep \romannumeral-‘0#1,\W,%
593 }%
594 \def\XINT_icstcv_prep
595 {%
596   \XINT_icstcv_loop_a {}1001%
597 }%
598 \def\XINT_icstcv_loop_a #1#2#3#4#5#6,%

```

```

599 {%
600   \xint_gob_til_W #6\XINT_icstcv_end\W
601   \expandafter
602   \XINT_icstcv_loop_b \romannumeral-‘0#6.{#2}{#3}{#4}{#5}{#1}%
603 }%
604 \def\XINT_icstcv_loop_b #1.#2#3#4#5%
605 {%
606   \expandafter\XINT_icstcv_loop_c\expandafter
607   {\romannumeral0\xintiiadd {#5}{\XINT_Mul {#1}{#3}}}%
608   {\romannumeral0\xintiiadd {#4}{\XINT_Mul {#1}{#2}}}%
609   {{#2}{#3}}}%
610 }%
611 \def\XINT_icstcv_loop_c #1#2%
612 {%
613   \expandafter\XINT_icstcv_loop_d\expandafter {#2}{#1}%
614 }%
615 \def\XINT_icstcv_loop_d #1#2%
616 {%
617   \expandafter\XINT_icstcv_loop_e\expandafter
618   {\romannumeral0\xintrawithzeros {#1/#2}}{#1}{#2}}%
619 }%
620 \def\XINT_icstcv_loop_e #1#2#3#4{\XINT_icstcv_loop_a {#4}{#1}}#2#3}%
621 \def\XINT_icstcv_end #1.#2#3#4#5#6{ #6}% 1.09b removes [0]

```

#### 41.20 \xintGctoCv

```

622 \def\xintGctoCv {\romannumeral0\xintgctocv }%
623 \def\xintgctocv #1%
624 {%
625   \expandafter\XINT_gctcv_prep \romannumeral-‘0#1+\W/%
626 }%
627 \def\XINT_gctcv_prep
628 {%
629   \XINT_gctcv_loop_a {}1001%
630 }%
631 \def\XINT_gctcv_loop_a #1#2#3#4#5#6+%
632 {%
633   \expandafter\XINT_gctcv_loop_b
634   \romannumeral0\xintrawithzeros {#6}.{#2}{#3}{#4}{#5}{#1}%
635 }%
636 \def\XINT_gctcv_loop_b #1/#2.#3#4#5#6%
637 {%
638   \expandafter\XINT_gctcv_loop_c\expandafter
639   {\romannumeral0\XINT_mul_fork #2\Z #4\Z }%
640   {\romannumeral0\XINT_mul_fork #2\Z #3\Z }%
641   {\romannumeral0\xintiiadd {\XINT_Mul {#2}{#6}}{\XINT_Mul {#1}{#4}}}%
642   {\romannumeral0\xintiiadd {\XINT_Mul {#2}{#5}}{\XINT_Mul {#1}{#3}}}%
643 }%
644 \def\XINT_gctcv_loop_c #1#2%
645 {%

```

```

646 \expandafter\XINT_gctcv_loop_d\expandafter {\expandafter{#2}{#1}}%
647 }%
648 \def\XINT_gctcv_loop_d #1#2%
649 {%
650 \expandafter\XINT_gctcv_loop_e\expandafter {\expandafter{#2}{#1}}%
651 }%
652 \def\XINT_gctcv_loop_e #1#2%
653 {%
654 \expandafter\XINT_gctcv_loop_f\expandafter {#2}#1%
655 }%
656 \def\XINT_gctcv_loop_f #1#2%
657 {%
658 \expandafter\XINT_gctcv_loop_g\expandafter
659 {\romannumeral0\xintraawithzeros {#1/#2}}{#1}{#2}}%
660 }%
661 \def\XINT_gctcv_loop_g #1#2#3#4%
662 {%
663 \XINT_gctcv_loop_h {#4{#1}}{#2#3}% 1.09b removes [0]
664 }%
665 \def\XINT_gctcv_loop_h #1#2#3/%
666 {%
667 \xint_gob_til_W #3\XINT_gctcv_end\W
668 \expandafter\XINT_gctcv_loop_i
669 \romannumeral0\xintraawithzeros {#3}.#2{#1}%
670 }%
671 \def\XINT_gctcv_loop_i #1/#2.#3#4#5#6%
672 {%
673 \expandafter\XINT_gctcv_loop_j\expandafter
674 {\romannumeral0\XINT_mul_fork #1\Z #6\Z }%
675 {\romannumeral0\XINT_mul_fork #1\Z #5\Z }%
676 {\romannumeral0\XINT_mul_fork #2\Z #4\Z }%
677 {\romannumeral0\XINT_mul_fork #2\Z #3\Z }%
678 }%
679 \def\XINT_gctcv_loop_j #1#2%
680 {%
681 \expandafter\XINT_gctcv_loop_k\expandafter {\expandafter{#2}{#1}}%
682 }%
683 \def\XINT_gctcv_loop_k #1#2%
684 {%
685 \expandafter\XINT_gctcv_loop_l\expandafter {\expandafter{#2}#1}%
686 }%
687 \def\XINT_gctcv_loop_l #1#2%
688 {%
689 \expandafter\XINT_gctcv_loop_m\expandafter {\expandafter{#2}#1}%
690 }%
691 \def\XINT_gctcv_loop_m #1#2{\XINT_gctcv_loop_a {#2}#1}%
692 \def\XINT_gctcv_end #1.#2#3#4#5#6{ #6}%

```

#### 41.21 \xintiGctoCv

```

693 \def\xintiGctoCv {\romannumeral0\xintigctocv }%
694 \def\xintigctocv #1%
695 {%
696   \expandafter\XINT_igctcv_prep \romannumeral-‘0#1+\W/%
697 }%
698 \def\XINT_igctcv_prep
699 {%
700   \XINT_igctcv_loop_a {}1001%
701 }%
702 \def\XINT_igctcv_loop_a #1#2#3#4#5#6+%
703 {%
704   \expandafter\XINT_igctcv_loop_b
705   \romannumeral-‘0#6.{#2}{#3}{#4}{#5}{#1}%
706 }%
707 \def\XINT_igctcv_loop_b #1.#2#3#4#5%
708 {%
709   \expandafter\XINT_igctcv_loop_c\expandafter
710   {\romannumeral0\xintiiadd {#5}{\XINT_Mul {#1}{#3}}}%
711   {\romannumeral0\xintiiadd {#4}{\XINT_Mul {#1}{#2}}}%
712   {{#2}{#3}}}%
713 }%
714 \def\XINT_igctcv_loop_c #1#2%
715 {%
716   \expandafter\XINT_igctcv_loop_f\expandafter {\expandafter{#2}{#1}}%
717 }%
718 \def\XINT_igctcv_loop_f #1#2#3#4/%
719 {%
720   \xint_gob_til_W #4\XINT_igctcv_end_a\W
721   \expandafter\XINT_igctcv_loop_g
722   \romannumeral-‘0#4.#1#2{#3}%
723 }%
724 \def\XINT_igctcv_loop_g #1.#2#3#4#5%
725 {%
726   \expandafter\XINT_igctcv_loop_h\expandafter
727   {\romannumeral0\XINT_mul_fork #1\Z #5\Z }%
728   {\romannumeral0\XINT_mul_fork #1\Z #4\Z }%
729   {{#2}{#3}}}%
730 }%
731 \def\XINT_igctcv_loop_h #1#2%
732 {%
733   \expandafter\XINT_igctcv_loop_i\expandafter {\expandafter{#2}{#1}}%
734 }%
735 \def\XINT_igctcv_loop_i #1#2{\XINT_igctcv_loop_k #2{#2#1}}%
736 \def\XINT_igctcv_loop_k #1#2%
737 {%
738   \expandafter\XINT_igctcv_loop_l\expandafter
739   {\romannumeral0\xintrawwithzeros {#1/#2}}%
740 }%
741 \def\XINT_igctcv_loop_l #1#2#3{\XINT_igctcv_loop_a {#3{#1}}#2}%1.09i removes [0]

```

```

742 \def\XINT_igctcv_end_a #1.#2#3#4#5%
743 {%
744   \expandafter\XINT_igctcv_end_b\expandafter
745   {\romannumeral0\xintraewithzeros {#2/#3}}%
746 }%
747 \def\XINT_igctcv_end_b #1#2{ #2{#1}}% 1.09b removes [0]

```

## 41.22 \xintCntoF

Modified in 1.06 to give the N first to a \numexpr rather than expanding twice. I just use \the\numexpr and maintain the previous code after that.

```

748 \def\xintCntoF {\romannumeral0\xintcntof }%
749 \def\xintcntof #1%
750 {%
751   \expandafter\XINT_cntf\expandafter {\the\numexpr #1}%
752 }%
753 \def\XINT_cntf #1#2%
754 {%
755   \ifnum #1>\xint_c_
756     \xint_afterfi {\expandafter\XINT_cntf_loop\expandafter
757                   {\the\numexpr #1-1\expandafter}\expandafter
758                   {\romannumeral-‘0#2{#1}}{#2}}%
759   \else
760     \xint_afterfi
761     {\ifnum #1=\xint_c_
762      \xint_afterfi {\expandafter\space \romannumeral-‘0#2{0}}%
763      \else \xint_afterfi { 0/1[0]}%
764      \fi}%
765   \fi
766 }%
767 \def\XINT_cntf_loop #1#2#3%
768 {%
769   \ifnum #1>\xint_c_ \else \XINT_cntf_exit \fi
770   \expandafter\XINT_cntf_loop\expandafter
771   {\the\numexpr #1-1\expandafter }\expandafter
772   {\romannumeral0\xintadd {\xintDiv {1[0]}{#2}}{#3{#1}}}%
773   {#3}%
774 }%
775 \def\XINT_cntf_exit \fi
776   \expandafter\XINT_cntf_loop\expandafter
777   #1\expandafter #2#3%
778 {%
779   \fi\xint_gobble_ii #2%
780 }%

```

## 41.23 \xintGCntoF

Modified in 1.06 to give the N first to a \numexpr rather than expanding twice. I just use \the\numexpr and maintain the previous code after that.

```

781 \def\xintGCntoF {\romannumeral0\xintgcntof }%
782 \def\xintgcntof #1%
783 {%
784   \expandafter\XINT_gcntf\expandafter {\the\numexpr #1}%
785 }%
786 \def\XINT_gcntf #1#2#3%
787 {%
788   \ifnum #1>\xint_c_
789     \xint_afterfi {\expandafter\XINT_gcntf_loop\expandafter
790                   {\the\numexpr #1-1\expandafter}\expandafter
791                   {\romannumeral-‘0#2{#1}}{#2}{#3}}%
792   \else
793     \xint_afterfi
794       {\ifnum #1=\xint_c_
795         \xint_afterfi {\expandafter\space\romannumeral-‘0#2{0}}%
796         \else \xint_afterfi { 0/1[0]}%
797         \fi}%
798   \fi
799 }%
800 \def\XINT_gcntf_loop #1#2#3#4%
801 {%
802   \ifnum #1>\xint_c_ \else \XINT_gcntf_exit \fi
803   \expandafter\XINT_gcntf_loop\expandafter
804   {\the\numexpr #1-1\expandafter }\expandafter
805   {\romannumeral0\xintadd {\xintDiv {#4{#1}}{#2}}{#3{#1}}}%
806   {#3}{#4}%
807 }%
808 \def\XINT_gcntf_exit \fi
809   \expandafter\XINT_gcntf_loop\expandafter
810   #1\expandafter #2#3#4%
811 {%
812   \fi\xint_gobble_ii #2%
813 }%

```

#### 41.24 \xintCntoCs

Modified in 1.06 to give the N first to a \numexpr rather than expanding twice. I just use \the\numexpr and maintain the previous code after that.

```

814 \def\xintCntoCs {\romannumeral0\xintcntocs }%
815 \def\xintcntocs #1%
816 {%
817   \expandafter\XINT_cntcs\expandafter {\the\numexpr #1}%
818 }%
819 \def\XINT_cntcs #1#2%
820 {%
821   \ifnum #1<0
822     \xint_afterfi { }% 1.09i: a 0/1[0] was strangely here, removed
823   \else

```

```

824 \xint_afterfi {\expandafter\XINT_cntcs_loop\expandafter
825               {\the\numexpr #1-1\expandafter}\expandafter
826               {\expandafter{\romannumeral-'\0#2{#1}}{#2}}}%
827 \fi
828 }%
829 \def\XINT_cntcs_loop #1#2#3%
830 {%
831   \ifnum #1>-1 \else \XINT_cntcs_exit \fi
832   \expandafter\XINT_cntcs_loop\expandafter
833   {\the\numexpr #1-1\expandafter }\expandafter
834   {\expandafter{\romannumeral-'\0#3{#1}},#2}{#3}%
835 }%
836 \def\XINT_cntcs_exit \fi
837 \expandafter\XINT_cntcs_loop\expandafter
838 #1\expandafter #2#3%
839 {%
840   \fi\XINT_cntcs_exit_b #2%
841 }%
842 \def\XINT_cntcs_exit_b #1,{ }%

```

### 41.25 \xintCntoGC

Modified in 1.06 to give the N first to a \numexpr rather than expanding twice. I just use \the\numexpr and maintain the previous code after that.

```

843 \def\xintCntoGC {\romannumeral0\xintcntogc }%
844 \def\xintcntogc #1%
845 {%
846   \expandafter\XINT_cntgc\expandafter {\the\numexpr #1}%
847 }%
848 \def\XINT_cntgc #1#2%
849 {%
850   \ifnum #1<0
851     \xint_afterfi { }% 1.09i there was as strange 0/1[0] here, removed
852   \else
853     \xint_afterfi {\expandafter\XINT_cntgc_loop\expandafter
854                   {\the\numexpr #1-1\expandafter}\expandafter
855                   {\expandafter{\romannumeral-'\0#2{#1}}{#2}}}%
856   \fi
857 }%
858 \def\XINT_cntgc_loop #1#2#3%
859 {%
860   \ifnum #1>-1 \else \XINT_cntgc_exit \fi
861   \expandafter\XINT_cntgc_loop\expandafter
862   {\the\numexpr #1-1\expandafter }\expandafter
863   {\expandafter{\romannumeral-'\0#3{#1}}+1/#2}{#3}%
864 }%
865 \def\XINT_cntgc_exit \fi
866 \expandafter\XINT_cntgc_loop\expandafter

```

```

867   #1\expandafter #2#3%
868 {%
869   \fi\XINT_cntgc_exit_b #2%
870 }%
871 \def\XINT_cntgc_exit_b #1+1/{ }%

```

#### 41.26 \xintGCntoGC

Modified in 1.06 to give the N first to a \numexpr rather than expanding twice. I just use \the\numexpr and maintain the previous code after that.

```

872 \def\xintGCntoGC {\romannumeral0\xintgcntogc }%
873 \def\xintgcntogc #1%
874 {%
875   \expandafter\XINT_gcntgc\expandafter {\the\numexpr #1}%
876 }%
877 \def\XINT_gcntgc #1#2#3%
878 {%
879   \ifnum #1<0
880     \xint_afterfi { }% 1.09i now returns nothing
881   \else
882     \xint_afterfi {\expandafter\XINT_gcntgc_loop\expandafter
883                   {\the\numexpr #1-1\expandafter}\expandafter
884                   {\expandafter{\romannumeral-'0#2{#1}}{#2}{#3}}}%
885   \fi
886 }%
887 \def\XINT_gcntgc_loop #1#2#3#4%
888 {%
889   \ifnum #1>-1 \else \XINT_gcntgc_exit \fi
890   \expandafter\XINT_gcntgc_loop_b\expandafter
891   {\expandafter{\romannumeral-'0#4{#1}}/#2}{#3{#1}}{#1}{#3}{#4}%
892 }%
893 \def\XINT_gcntgc_loop_b #1#2#3%
894 {%
895   \expandafter\XINT_gcntgc_loop\expandafter
896   {\the\numexpr #3-1\expandafter}\expandafter
897   {\expandafter{\romannumeral-'0#2}+#1}%
898 }%
899 \def\XINT_gcntgc_exit \fi
900   \expandafter\XINT_gcntgc_loop_b\expandafter #1#2#3#4#5%
901 {%
902   \fi\XINT_gcntgc_exit_b #1%
903 }%
904 \def\XINT_gcntgc_exit_b #1/{ }%

```

#### 41.27 \xintCstoGC

```

905 \def\xintCstoGC {\romannumeral0\xintcstogc }%
906 \def\xintcstogc #1%

```

```

907 {%
908   \expandafter\XINT_cstc_prep \romannumeral-‘0#1,\W,%
909 }%
910 \def\XINT_cstc_prep #1,{\XINT_cstc_loop_a {{#1}}}%
911 \def\XINT_cstc_loop_a #1#2,%
912 {%
913   \xint_gob_til_W #2\XINT_cstc_end\W
914   \XINT_cstc_loop_b {#1}{#2}%
915 }%
916 \def\XINT_cstc_loop_b #1#2{\XINT_cstc_loop_a {#1+1/{#2}}}%
917 \def\XINT_cstc_end\W\XINT_cstc_loop_b #1#2{ #1}%

```

#### 41.28 \xintGctoGC

```

918 \def\xintGctoGC {\romannumeral0\xintgctogc }%
919 \def\xintgctogc #1%
920 {%
921   \expandafter\XINT_gctgc_start \romannumeral-‘0#1+\W/%
922 }%
923 \def\XINT_gctgc_start {\XINT_gctgc_loop_a {}}%
924 \def\XINT_gctgc_loop_a #1#2+#3/%
925 {%
926   \xint_gob_til_W #3\XINT_gctgc_end\W
927   \expandafter\XINT_gctgc_loop_b\expandafter
928   {\romannumeral-‘0#2}{#3}{#1}%
929 }%
930 \def\XINT_gctgc_loop_b #1#2%
931 {%
932   \expandafter\XINT_gctgc_loop_c\expandafter
933   {\romannumeral-‘0#2}{#1}%
934 }%
935 \def\XINT_gctgc_loop_c #1#2#3%
936 {%
937   \XINT_gctgc_loop_a {#3{#2}+{#1}}/%
938 }%
939 \def\XINT_gctgc_end\W\expandafter\XINT_gctgc_loop_b
940 {%
941   \expandafter\XINT_gctgc_end_b
942 }%
943 \def\XINT_gctgc_end_b #1#2#3{ #3{#1}}%
944 \XINT_restorecatcodes_endinput%

```

## 42 Package *xintexpr* implementation

The first version was released in June 2013. I was greatly helped in this task of writing an expandable parser of infix operations by the comments provided in `l3fp-parse.dtx`. One will recognize in particular the idea of the ‘until’ macros; I have not looked into the actual `l3fp` code beyond the very useful comments provided in its documentation.

A main worry was that my data has no a priori bound on its size; to keep the code reasonably

efficient, I experimented with a technique of storing and retrieving data expandably as *names* of control sequences. Intermediate computation results are stored as control sequences `\.=a/b[n]`.

Another peculiarity is that the input is allowed to contain (but only where the scanner looks for a number or fraction) material within braces `{...}`. This will be expanded completely and must give an integer, decimal number or fraction (not in scientific notation). Conversely any fraction (or macro giving on expansion one such; this does not apply to intermediate computation results, only to user input) in the `A/B[n]` format *with the brackets* **must** be enclosed in such braces, square brackets are not acceptable by the expression parser.

These two things are a bit *experimental* and perhaps I will opt for another approach at a later stage. To circumvent the potential hash-table impact of the `\.=a/b[n]` I have provided the macro creators `\xintNewExpr` and `\xintNewFloatExpr`.

Roughly speaking, the parser mechanism is as follows: at any given time the last found “operator” has its associated `until` macro awaiting some news from the token flow; first `getnext` expands forward in the hope to construct some number, which may come from a parenthesized sub-expression, from some braced material, or from a digit by digit scan. After this number has been formed the next operator is looked for by the `getop` macro. Once `getop` has finished its job, `until` is presented with three tokens: the first one is the precedence level of the new found operator (which may be an end of expression marker), the second is the operator character token (earlier versions had here already some macro name, but in order to keep as much common code to `expr` and `floatexpr` common as possible, this was modied) of the new found operator, and the third one is the newly found number (which was encountered just before the new operator).

The `until` macro of the earlier operator examines the precedence level of the new found one, and either executes the earlier operator (in the case of a binary operation, with the found number and a previously stored one) or it delays execution, giving the hand to the `until` macro of the operator having been found of higher precedence.

A minus sign acting as prefix gets converted into a (unary) operator inheriting the precedence level of the previous operator.

Once the end of the expression is found (it has to be marked by a `\relax`) the final result is output as four tokens: the first one a catcode 11 exclamation mark, the second one an error generating macro, the third one a printing macro and the fourth is `\.=a/b[n]`. The prefix `\xintthe` makes the output printable by killing the first two tokens.

Version 1.08b [2013/06/14] corrected a problem originating in the attempt to attribute a special rôle to braces: expansion could be stopped by space tokens, as various macros tried to expand without grabbing what came next. They now have a doubled `\romannumeral-‘0`.

Version 1.09a [2013/09/24] has a better mechanism regarding `\xintthe`, more commenting and better organization of the code, and most importantly it implements functions, comparison operators, logic operators, conditionals. The code was reorganized and expansion proceeds a bit differently in order to have the `_getnext` and `_getop` codes entirely shared by `\xintexpr` and `\xintfloatexpr`. `\xintNewExpr` was rewritten in order to work with the standard macro parameter character `#`, to be catcode protected and to also allow comma separated expressions.

Version 1.09c [2013/10/09] added the `bool` and `togl` operators, `\xintboolexpr`, and `\xintNewNumExpr`, `\xintNewBoolExpr`. The code for `\xintNewExpr` is shared with `float`, `num`, and `bool`-expressions. Also the precedence level of the postfix operators `!`, `?` and `:` has been made lower than the

one of functions.

Version 1.09i [2013/12/18] unpacks count and dimen registers and control sequences, with tacit multiplication. It has also made small improvements (speed gains in macro expansions in quite a few places).

Also, 1.09i implements `\xintiexpr`, `\xinttheiexpr`. New function `frac`. And encapsulation in `\csname... \endcsname` is done with `.` as first tokens, so unpacking with `\string` can be done in a completely escape char agnostic way.

Version 1.09j [2014/01/09] extends the tacit multiplication to the case of a sub `\xintexpr`-essions. Also, it now `\xint_protects` the result of the `\xintexpr` full expansions, thus, an `\xintexpr` without `\xintthe` prefix can be used not only as the first item within an “`\fdef`” as previously but also now anywhere within an `\edef`. Five tokens are used to pack the computation result rather than the possibly hundreds or thousands of digits of an `\xintthe` unlocked result. I deliberately omit a second `\xint_protect` which, however would be necessary if some macro `\.=digits/digits[digits]` had acquired some expandable meaning elsewhere. But this seems not that probable, and adding the protection would mean impacting everything only to allow some crazy user which has loaded something else than `xint` to do an `\edef... the \xintexpr` computations are otherwise in no way affected if such control sequences have a meaning.

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### 42.1 Catcodes, $\varepsilon$ -TeX and reload detection

The code for reload detection is copied from HEIKO OBERDIEK’s packages, and adapted here to check for previous loading of the **xintfrac** package.

The method for catcodes is slightly different, but still directly inspired by these packages.

```

1 \begingroup\catcode61\catcode48\catcode32=10\relax%
2 \catcode13=5 % ^^M
3 \endlinechar=13 %

```

```

4 \catcode123=1 % {
5 \catcode125=2 % }
6 \catcode64=11 % @
7 \catcode35=6 % #
8 \catcode44=12 % ,
9 \catcode45=12 % -
10 \catcode46=12 % .
11 \catcode58=12 % :
12 \def\space { }%
13 \let\z\endgroup
14 \expandafter\let\expandafter\x\csname ver@xintexpr.sty\endcsname
15 \expandafter\let\expandafter\w\csname ver@xintfrac.sty\endcsname
16 \expandafter
17 \ifx\csname PackageInfo\endcsname\relax
18 \def\y#1#2{\immediate\write-1{Package #1 Info: #2.}}%
19 \else
20 \def\y#1#2{\PackageInfo{#1}{#2}}%
21 \fi
22 \expandafter
23 \ifx\csname numexpr\endcsname\relax
24 \y{xintexpr}{numexpr not available, aborting input}%
25 \aftergroup\endinput
26 \else
27 \ifx\x\relax % plain-TeX, first loading of xintexpr.sty
28 \ifx\w\relax % but xintfrac.sty not yet loaded.
29 \y{xintexpr}{now issuing \string\input\space xintfrac.sty}%
30 \def\z{\endgroup\input xintfrac.sty\relax}%
31 \fi
32 \else
33 \def\empty {}%
34 \ifx\x\empty % LaTeX, first loading,
35 % variable is initialized, but \ProvidesPackage not yet seen
36 \ifx\w\relax % xintfrac.sty not yet loaded.
37 \y{xintexpr}{now issuing \string\RequirePackage{xintfrac}}%
38 \def\z{\endgroup\RequirePackage{xintfrac}}%
39 \fi
40 \else
41 \y{xintexpr}{I was already loaded, aborting input}%
42 \aftergroup\endinput
43 \fi
44 \fi
45 \fi
46 \z%

```

## 42.2 Confirmation of *xintfrac* loading

```

47 \begingroup\catcode61\catcode48\catcode32=10\relax%
48 \catcode13=5 % ^^M
49 \endlinechar=13 %

```

```

50 \catcode123=1 % {
51 \catcode125=2 % }
52 \catcode64=11 % @
53 \catcode35=6 % #
54 \catcode44=12 % ,
55 \catcode45=12 % -
56 \catcode46=12 % .
57 \catcode58=12 % :
58 \ifdefined\PackageInfo
59 \def\y#1#2{\PackageInfo{#1}{#2}}%
60 \else
61 \def\y#1#2{\immediate\write-1{Package #1 Info: #2.}}%
62 \fi
63 \def\empty {}%
64 \expandafter\let\expandafter\w\csname ver@xintfrac.sty\endcsname
65 \ifx\w\relax % Plain TeX, user gave a file name at the prompt
66 \y{xintexpr}{Loading of package xintfrac failed, aborting input}%
67 \aftergroup\endinput
68 \fi
69 \ifx\w\empty % LaTeX, user gave a file name at the prompt
70 \y{xintexpr}{Loading of package xintfrac failed, aborting input}%
71 \aftergroup\endinput
72 \fi
73 \endgroup%

```

### 42.3 Catcodes

```
74 \XINTsetupcatcodes%
```

### 42.4 Package identification

```

75 \XINT_providespackage
76 \ProvidesPackage{xintexpr}%
77 [2014/01/09 v1.09j Expandable expression parser (jfb)]%

```

### 42.5 Encapsulation in pseudo cs names, helper macros

1.09i uses `.=` for encapsulation, thus allowing `\escapechar` to be anything (all previous releases were with `.`, so `\escapechar 46` was forbidden). Besides, the `\edef` definition has `\space` already expanded, perhaps this will compensate a tiny bit the time penalty of `'.=` viz `'.` in unlocking... well not really, I guess.

```

78 \def\xint_gob_til_! #1!{% nota bene: this ! has catcode 11
79 \edef\XINT_expr_lock #1!%
80 {\noexpand\expandafter\space\noexpand\csname .=#1\noexpand\endcsname }%
81 \def\XINT_expr_unlock {\expandafter\XINT_expr_unlock_a\string}%
82 \def\XINT_expr_unlock_a #1.={%}%
83 \def\XINT_expr_unexpectedtoken {\xintError:ignored}%
84 \def\XINT_newexpr_setprefix #1>{\noexpand\romannumeral-'0}%
85 \def\xint_UDxintrelaxfork #1\xint_relax #2#3\krof {#2}%

```

## 42.6 \xintexpr, \xinttheexpr, \xintthe, ...

\xintthe is defined with a parameter, I guess I wanted to make sure no stray space tokens could cause a problem.

With 1.09i, \xintiexpr replaces \xintnumexpr which is kept for compatibility but will be removed at some point. Should perhaps issue a warning, but well, people can also read the documentation. Also 1.09i removes \xinttheeval.

1.09i has re-organized the material here.

1.09j modifies the mechanism of \XINT\_expr\_usethe and \XINT\_expr\_print, etc... in order for \xintexpr-essions to be usable within \edef'initions. I hesitated quite a bit with adding \xint\_protect in front of the \.=digits macros, which will in 99.99999% of use cases supposed all have \relax meaning; and it is a bit of a pain, really, it is quite a pain to add these extra tokens only for \edef contexts and for situations which will never occur... well no damn't let's \*NOT\* add this extra \xint\_protect. Just one before the printing macro (which can not be \protected, else \xintthe could not work).

```

86 \def\xint_protect {\noexpand\xint_protect\noexpand }% 1.09j
87 \def\XINT_expr_done {\XINT_expr_usethe\xint_protect\XINT_expr_print }%
88 \let\XINT_iexpr_done \XINT_expr_done
89 \def\XINT_iexpr_done {\XINT_expr_usethe\xint_protect\XINT_iexpr_print }%
90 \def\XINT_flexpr_done {\XINT_expr_usethe\xint_protect\XINT_flexpr_print }%
91 \def\XINT_boolexpr_done {\XINT_expr_usethe\xint_protect\XINT_boolexpr_print }%
92 \protected\def\XINT_expr_usethe #1#2#3% modified in 1.09j
93 {\xintError:missing_xintthe!\show#3missing xintthe (see log)!}%
94 \def\xintthe #1{\romannumeral-‘0\expandafter\xint_gobble_iii\romannumeral-‘0#1}%
95 \let\XINT_expr_print \XINT_expr_unlock
96 \def\XINT_iexpr_print #1{\xintRound:csv {\XINT_expr_unlock #1}}%
97 \def\XINT_flexpr_print #1{\xintFloat:csv {\XINT_expr_unlock #1}}%
98 \def\XINT_boolexpr_print #1{\xintIsTrue:csv {\XINT_expr_unlock #1}}%
99 \def\xintexpr {\romannumeral0\xinteval }%
100 \def\xintfloatexpr {\romannumeral0\xintfloateval }%
101 \def\xintiexpr {\romannumeral0\xintiieval }%
102 \def\xinteval
103 {\expandafter\XINT_expr_until_end_a \romannumeral-‘0\XINT_expr_getnext }%
104 \def\xintfloateval
105 {\expandafter\XINT_flexpr_until_end_a\romannumeral-‘0\XINT_expr_getnext }%
106 \def\xintiieval
107 {\expandafter\XINT_iexpr_until_end_a\romannumeral-‘0\XINT_expr_getnext }%
108 \def\xinttheexpr
109 {\romannumeral-‘0\expandafter\xint_gobble_iii\romannumeral0\xinteval }%
110 \def\xintthefloatexpr
111 {\romannumeral-‘0\expandafter\xint_gobble_iii\romannumeral0\xintfloateval }%
112 \def\xinttheiexpr
113 {\romannumeral-‘0\expandafter\xint_gobble_iii\romannumeral0\xintiieval }%
114 \def\xintiexpr {\romannumeral0\expandafter\expandafter\expandafter
115 \XINT_iexpr_done \expandafter\xint_gobble_iv\romannumeral0\xinteval }%
116 \def\xinttheiexpr {\romannumeral-‘0\expandafter\expandafter\expandafter
117 \XINT_iexpr_print\expandafter\xint_gobble_iv\romannumeral0\xinteval }%

```

```

118 \def\xintboolexpr      {\romannumeral0\expandafter\expandafter\expandafter
119   \XINT_boolexpr_done \expandafter\xint_gobble_iv\romannumeral0\xinteval }%
120 \def\xinttheboolexpr    {\romannumeral-‘0\expandafter\expandafter\expandafter
121   \XINT_boolexpr_print\expandafter\xint_gobble_iv\romannumeral0\xinteval }%
122 \let\xintnumexpr        \xintiexpr      % deprecated
123 \let\xintthenumexpr\xinttheiexpr % deprecated

```

## 42.7 \xintifboolexpr, \xintifboolfloatexpr, cshxintifboolliexpr

1.09c. Does not work with comma separated expressions. I could make use \xintORof:csv (or AND, or XOR) to allow it, but don't know if the overhead is worth it.

1.09i adds \xintifboolliexpr

```

124 \def\xintifboolexpr #1%
125     {\romannumeral0\xintifnotzero {\xinttheexpr #1\relax}}%
126 \def\xintifboolfloatexpr #1%
127     {\romannumeral0\xintifnotzero {\xintthefloatexpr #1\relax}}%
128 \def\xintifboolliexpr #1%
129     {\romannumeral0\xintifnotzero {\xinttheiexpr #1\relax}}%

```

## 42.8 \XINT\_get\_next: looking for a number

June 14: 1.08b adds a second \romannumeral-‘0 to \XINT\_expr\_getnext in an attempt to solve a problem with space tokens stopping the \romannumeral and thus preventing expansion of the following token. For example: 1+ \the\cnta caused a problem, as ‘\the’ was not expanded. I did not define \XINT\_expr\_getnext as a macro with parameter (which would have cured preventively this), precisely to try to recognize brace pairs. The second \romannumeral-‘0 is added for the same reason in other places.

The get-next scans forward to find a number: after expansion of what comes next, an opening parenthesis signals a parenthesized sub-expression, a ! with catcode 11 signals there was there an \xintexpr.. \relax sub-expression (now evaluated), a minus is a prefix operator, a plus is silently ignored, a digit or decimal point signals to start gathering a number, braced material {...} is allowed and will be directly fed into a \csname...\endcsname for complete expansion which must deliver a (fractional) number, possibly ending in [n]; explicit square brackets must be enclosed into such braces. Once a number issues from the previous procedures, it is a locked into a \csname...\endcsname, and the flow then proceeds with \XINT\_expr\_getop which will scan for an infix or postfix operator following the number.

A special r^ole is played by underscores \_ for use with \xintNewExpr to input macro parameters.

Release 1.09a implements functions; the idea is that a letter (actually, anything not otherwise recognized!) triggers the function name gatherer, the comma is promoted to a binary operator of priority intermediate between parentheses and infix operators. The code had some other revisions in order for all the \_getnext and \_getop macros to now be shared by \xintexpr and \xintflexpr.

1.09i now allows direct insertion of `\count`'s, `\dimen`'s and `\skip`'s which will be unpacked using `\number`.

1.09i speeds up a bit the recognition of a braced thing: the case of a single braced control sequence makes a third expansion mandatory, let's do it immediately and not wait. So macros got shuffled and modified a bit.

`\XINT_expr_unpackvariable` does not insert a `[0]` for compatibility with `\xinttiexpr`. A `[0]` would have made a bit faster `\xintexpr` macros when dealing with an unpacked count control sequence, as without it the `\xintnum` will be used in the parsing by `xintfrac` macros when the number is used. But `[0]` is not accepted by most macros ultimately called by `\xinttiexpr`.

```

130 \def\XINT_expr_getnext
131 {%
132   \expandafter\XINT_expr_getnext_checkforbraced_a
133   \romannumeral-'0\romannumeral-'0%
134 }%
135 \def\XINT_expr_getnext_checkforbraced_a #1% was done later in <1.09i
136 {%
137   \expandafter\XINT_expr_getnext_checkforbraced_b\expandafter
138   {\romannumeral-'0#1}%
139 }%
140 \def\XINT_expr_getnext_checkforbraced_b #1%
141 {%
142   \XINT_expr_getnext_checkforbraced_c #1\xint_relax\Z {#1}%
143 }%
144 \def\XINT_expr_getnext_checkforbraced_c #1#2%
145 {%
146   \xint_UDxintrelaxfork
147       #1\XINT_expr_getnext_wasemptyorspace
148       #2\XINT_expr_getnext_gotonetoken_wehope
149   \xint_relax\XINT_expr_getnext_gotbracedstuff
150   \krof
151 }% doubly braced things are not acceptable, will cause errors.
152 \def\XINT_expr_getnext_wasemptyorspace #1{\XINT_expr_getnext }%
153 \def\XINT_expr_getnext_gotbracedstuff #1\xint_relax\Z #2%
154 {%
155   \expandafter\XINT_expr_gettop\csname .=#2\endcsname
156 }%
157 \def\XINT_expr_getnext_gotonetoken_wehope\Z #1%
158 {% screens out sub-expressions and \count or \dimen registers/variables
159   \xint_gob_til_! #1\XINT_expr_subexpr !% recall this ! has catcode 11
160   \ifcat\relax#1% \count or \numexpr etc... token or count, dimen, skip cs
161     \expandafter\XINT_expr_countdimenetc_fork
162   \else
163     \expandafter\expandafter\expandafter
164     \XINT_expr_getnext_onetoken_fork\expandafter\string
165   \fi
166   #1%
167 }%

```

```

168 \def\XINT_expr_subexpr !#1\fi !{\expandafter\XINT_expr_getop\xint_gobble_iii }%
169 \def\XINT_expr_countdimenetc_fork #1%
170 {%
171   \ifx\count#1\else\ifx#1\dimen\else\ifx#1\numexpr\else\ifx#1\dimexpr\else
172   \ifx\skip#1\else\ifx\glueexpr#1\else
173     \XINT_expr_unpackvariable
174   \fi\fi\fi\fi\fi\fi
175   \expandafter\XINT_expr_getnext\number #1%
176 }%
177 \def\XINT_expr_unpackvariable\fi\fi\fi\fi\fi\fi\expandafter\XINT_expr_getnext
178   \number #1{\fi\fi\fi\fi\fi\fi
179   \expandafter\XINT_expr_getop\csname .=\number#1\endcsname }%

```

1.09a: In order to have this code shared by `\xintexpr` and `\xintfloatexpr`, I have moved to the until macros the responsibility to choose `expr` or `floatexpr`, hence here, the opening parenthesis for example can not be triggered directly as it would not know in which context it works. Hence the `\xint_c_xviii` (`{}`). And also the mechanism of `\xintNewExpr` has been modified to allow use of `#`.

1.09i also has `\xintiexpr`.

```

180 \begingroup
181 \lccode'*= '#
182 \lowercase{\endgroup
183 \def\XINT_expr_sixwayfork #1(-.*#2#3\krof {#2}%
184 \def\XINT_expr_getnext_onetoken_fork #1%
185 {% The * is in truth catcode 12 #. For (hacking) use with \xintNewExpr.
186   \XINT_expr_sixwayfork
187     #1-.*{\xint_c_xviii ({})}% back to until for oparen triggering
188     (#1.*{-}%
189     (-#1.*{\XINT_expr_scandec_II .}%
190     (-.#1*{\XINT_expr_getnext }%
191     (-.*#1{\XINT_expr_scandec_II }%
192     (-.*{\XINT_expr_scan_dec_or_func #1}%
193   \krof
194 }%

```

## 42.9 `\XINT_expr_scan_dec_or_func`: collecting an integer or decimal number or function name

`\XINT_expr_scanfunc_b` rewritten in 1.09i

```

195 \def\XINT_expr_scan_dec_or_func #1% this #1 has necessarily here catcode 12
196 {%
197   \ifnum \xint_c_ix<1#1
198     \expandafter\XINT_expr_scandec_I
199   \else % We assume we are dealing with a function name!!
200     \expandafter\XINT_expr_scanfunc
201   \fi #1%
202 }%

```

```

203 \def\XINT_expr_scanfunc
204 {%
205   \expandafter\XINT_expr_func\romannumeral-‘0\XINT_expr_scanfunc_c
206 }%
207 \def\XINT_expr_scanfunc_c #1%
208 {%
209   \expandafter #1\romannumeral-‘0\expandafter
210   \XINT_expr_scanfunc_a\romannumeral-‘0\romannumeral-‘0%
211 }%
212 \def\XINT_expr_scanfunc_a #1% please no braced things here!
213 {%
214   \ifcat #1\relax % missing opening parenthesis, probably
215     \expandafter\XINT_expr_scanfunc_panic
216   \else
217     \xint_afterfi{\expandafter\XINT_expr_scanfunc_b \string #1}%
218   \fi
219 }%
220 \def\xint_UDparenfork #1()#2#3\krof {#2}%
221 \def\XINT_expr_scanfunc_b #1%
222 {%
223   \xint_UDparenfork
224     #1){}% and then \XINT_expr_func
225     (#1){}% and then \XINT_expr_func (this is for bool/toggle names)
226     ){ \XINT_expr_scanfunc_c #1}%
227   \krof
228 }%
229 \def\XINT_expr_scanfunc_panic {\xintError:bigtroubleahead(0\relax }%
230 \def\XINT_expr_func #1(% common to expr and flexpr and iexpr
231 {%
232   \xint_c_xviii @#{1}% functions have the highest priority.
233 }%

Scanning for a number of fraction. Once gathered, lock it and do _getop. 1.09i mod-
ifies \XINT_expr_scanintpart_a (splits_aa) and also \XINT_expr_scanfracpart_a
in order for the tacit multiplication of \count's and \dimen's to be compatible
with escape-char=a digit.
1.09j further extends to recognize an \xintexpr (or cousin) and then insert
automatically a * (done in \XINT_expr_getop).

234 \def\XINT_expr_scandec_I
235 {%
236   \expandafter\XINT_expr_getop\romannumeral-‘0\expandafter
237   \XINT_expr_lock\romannumeral-‘0\XINT_expr_scanintpart_b
238 }%
239 \def\XINT_expr_scandec_II
240 {%
241   \expandafter\XINT_expr_getop\romannumeral-‘0\expandafter
242   \XINT_expr_lock\romannumeral-‘0\XINT_expr_scanfracpart_b
243 }%
244 \def\XINT_expr_scanintpart_a #1% Please no braced material: 123{FORBIDDEN}

```

```

245 {% careful that ! has catcode letter... spaces needed after <cs>...
246   \ifcat #1\relax
247     \expandafter !% stop number scan if \relax, \count, \numexpr, or
248   \else \xint_afterfi{\ifx !#1\expandafter !\else % also \xintexpr etc..
249     \expandafter\expandafter\expandafter
250     \XINT_expr_scanintpart_aa\expandafter\string\fi }%
251   \fi #1%
252 }%
253 \def\XINT_expr_scanintpart_aa #1%
254 {%
255   \ifnum \xint_c_ix<1#1
256     \expandafter\XINT_expr_scanintpart_b
257   \else
258     \if .#1%
259       \expandafter\expandafter\expandafter
260       \XINT_expr_scandec_transition
261     \else % gather what we got so far, leave catcode 12 #1 in stream
262       \expandafter\expandafter\expandafter !% ! of catcode 11, space needed
263     \fi
264   \fi
265   #1%
266 }%
267 \def\XINT_expr_scanintpart_b #1%
268 {%
269   \expandafter #1\romannumeral-'0\expandafter
270   \XINT_expr_scanintpart_a\romannumeral-'0\romannumeral-'0%
271 }%
272 \def\XINT_expr_scandec_transition #1%
273 {%
274   \expandafter.\romannumeral-'0\expandafter
275   \XINT_expr_scanfracpart_a\romannumeral-'0\romannumeral-'0%
276 }%
277 \def\XINT_expr_scanfracpart_a #1%
278 {%
279   \ifcat #1\relax
280     \expandafter !% stop number scan
281   \else \xint_afterfi{\ifx !#1\expandafter !\else
282     \expandafter\expandafter\expandafter
283     \XINT_expr_scanfracpart_aa\expandafter\string\fi }%
284   \fi #1%
285 }%
286 \def\XINT_expr_scanfracpart_aa #1%
287 {%
288   \ifnum \xint_c_ix<1#1
289     \expandafter\XINT_expr_scanfracpart_b
290   \else
291     \expandafter !%
292   \fi
293   #1%

```

```

294 }%
295 \def\XINT_expr_scanfracpart_b #1%
296 {%
297   \expandafter #1\romannumeral-'0\expandafter
298   \XINT_expr_scanfracpart_a\romannumeral-'0\romannumeral-'0%
299 }%

```

## 42.10 \XINT\_expr\_getop: looking for an operator

June 14 (1.08b): I add here a second \romannumeral-'0, because \XINT\_expr\_getnext and others try to expand the next token but without grabbing it.

This finds the next infix operator or closing parenthesis or postfix exclamation mark ! or expression end. It then leaves in the token flow <precedence> <operator> <locked number>. The <precedence> is generally a character command which thus stops expansion and gives back control to an \XINT\_expr\_until\_<op> command; or it is the minus sign which will be converted by a suitable \XINT\_expr\_checkifprefix\_<p> into an operator with a given inherited precedence. Earlier releases than 1.09c used tricks for the postfix !, ?, :, with <precedence> being in fact a macro to act immediately, and then re-activate \XINT\_expr\_getop.

In versions earlier than 1.09a the <operator> was already made in to a control sequence; but now it is a left as a token and will be (generally) converted by the until macro which knows if it is in a \xintexpr or an \xintfloatexpr. (or an \xintiexpr, since 1.09i)

1.09i allows \count's, \dimen's, \skip's with tacit multiplication.

1.09j extends the mechanism of tacit multiplication to the case of a sub xint-expression in its various variants. Careful that our ! has catcode 11 so \ifx! would be a disaster...

```

300 \def\XINT_expr_getop #1% this #1 is the current locked computed value
301 {% full expansion of next token, first swallowing a possible space
302   \expandafter\XINT_expr_getop_a\expandafter #1%
303   \romannumeral-'0\romannumeral-'0%
304 }%
305 \def\XINT_expr_getop_a #1#2%
306 {% if a control sequence is found, must be either \relax or register|variable
307   \ifcat #2\relax\expandafter\xint_firstoftwo
308     \else \expandafter\xint_secondoftwo
309   \fi
310   {\ifx #2\relax\expandafter\xint_firstofthree
311     \else\expandafter\xint_secondofthree % tacit multiplication
312   \fi }%
313   {\ifx !#2\expandafter\xint_secondofthree % tacit multiplication
314     \else\expandafter\xint_thirdofthree
315   \fi }%
316   {\XINT_expr_foundend #1}%
317   {\XINT_expr_foundop *#1#2}%
318   {\XINT_expr_foundop #2#1}%
319 }%
320 \def\XINT_expr_foundend {\xint_c_ \relax }% \relax is a place holder here.

```

```

321 \def\XINT_expr_foundop #1% then becomes <prec> <op> and is followed by <\.=f>
322 {% 1.09a: no control sequence \XINT_expr_op_#1, code common to expr/flexpr
323   \ifcsname XINT_expr_precedence_#1\endcsname
324     \expandafter\xint_afterfi\expandafter
325     {\csname XINT_expr_precedence_#1\endcsname #1}%
326   \else
327     \XINT_expr_unexpectedtoken
328     \expandafter\XINT_expr_getop
329   \fi
330 }%

```

## 42.11 Parentheses

1.09a removes some doubling of \romannumeral-‘\0 from 1.08b which served no useful purpose here (I think...).

```

331 \def\XINT_tmpa #1#2#3#4#5%
332 {%
333   \def#1##1%
334   {%
335     \xint_UDsignfork
336       ##1{\expandafter#1\romannumeral-‘0#3}%
337       -{#2##1}%
338     \krof
339   }%
340   \def#2##1##2%
341   {%
342     \ifcase ##1\expandafter #4%
343     \or\xint_afterfi{%
344       \XINT_expr_extra_closing_paren
345       \expandafter #1\romannumeral-‘0\XINT_expr_getop
346     }%
347     \else
348     \xint_afterfi{\expandafter#1\romannumeral-‘0\csname XINT_#5_op_##2\endcsname }%
349     \fi
350   }%
351 }%
352 \xintFor #1 in {expr,flexpr,iiexpr} \do {%
353 \expandafter\XINT_tmpa
354   \csname XINT_#1_until_end_a\expandafter\endcsname
355   \csname XINT_#1_until_end_b\expandafter\endcsname
356   \csname XINT_#1_op_-vi\expandafter\endcsname
357   \csname XINT_#1_done\endcsname
358   {#1}%
359 }%
360 \def\XINT_expr_extra_closing_paren {\xintError:removed }%
361 \def\XINT_tmpa #1#2#3#4#5#6%
362 {%
363   \def #1{\expandafter #3\romannumeral-‘0\XINT_expr_getnext }%

```

```

364 \let #2#1%
365 \def #3##1{\xint_UDsignfork
366     ##1{\expandafter #3\romannumeral-‘0#5}%
367     -{#4##1}%
368     \krof }%
369 \def #4##1##2%
370 {%
371     \ifcase ##1\expandafter \XINT_expr_missing_cparen
372     \or \expandafter \XINT_expr_getop
373     \else \xint_afterfi
374     {\expandafter #3\romannumeral-‘0\csname XINT_#6_op_##2\endcsname }%
375     \fi
376 }%
377}%
378\xintFor #1 in {expr,flexpr,iiexpr} \do {%
379\expandafter\XINT_tmpa
380 \csname XINT_#1_op_(\expandafter\endcsname
381 \csname XINT_#1_oparen\expandafter\endcsname
382 \csname XINT_#1_until_)_a\expandafter\endcsname
383 \csname XINT_#1_until_)_b\expandafter\endcsname
384 \csname XINT_#1_op_-vi\endcsname
385 {#1}%
386}%
387\def\XINT_expr_missing_cparen {\xintError:inserted \xint_c_ \XINT_expr_done }%
388\expandafter\let\csname XINT_expr_precedence_\endcsname \xint_c_i
389\expandafter\let\csname XINT_flexpr_precedence_\endcsname \xint_c_i
390\expandafter\let\csname XINT_iiexpr_precedence_\endcsname \xint_c_i
391\expandafter\let\csname XINT_expr_op_\endcsname \XINT_expr_getop
392\expandafter\let\csname XINT_flexpr_op_\endcsname\XINT_expr_getop
393\expandafter\let\csname XINT_iiexpr_op_\endcsname\XINT_expr_getop

```

## 42.12 The `\XINT_expr_until_<op>` macros for boolean operators, comparison operators, arithmetic operators, scientific notation.

Extended in 1.09a with comparison and boolean operators. 1.09i adds `\xintiexpr` and incorporates optional part `[\XINTdigits]` for a tiny bit faster float operations now already equipped with their optional argument

```

394 \def\XINT_tmppb #1#2#3#4#5#6#7%
395 {%
396     \expandafter\XINT_tmppc
397     \csname XINT_#1_op_#3\expandafter\endcsname
398     \csname XINT_#1_until_#3_a\expandafter\endcsname
399     \csname XINT_#1_until_#3_b\expandafter\endcsname
400     \csname XINT_#1_op_-#5\expandafter\endcsname
401     \csname xint_c_#4\expandafter\endcsname
402     \csname #2#6\expandafter\endcsname
403     \csname XINT_expr_precedence_#3\endcsname {#1}%{#7}%

```

```

404 }%
405 \def\XINT_tmpc #1#2#3#4#5#6#7#8#9%
406 {%
407   \def #1##1% \XINT_expr_op_<op>
408   {% keep value, get next number and operator, then do until
409     \expandafter #2\expandafter ##1%
410     \romannumeral-'0\expandafter\XINT_expr_getnext
411   }%
412   \def #2##1##2% \XINT_expr_until_<op>_a
413   {\xint_UDsignfork
414     ##2{\expandafter #2\expandafter ##1\romannumeral-'0#4}%
415     -{#3##1##2}%
416     \krof }%
417   \def #3##1##2##3##4% \XINT_expr_until_<op>_b
418   {% either execute next operation now, or first do next (possibly unary)
419     \ifnum ##2>#5%
420       \xint_afterfi {\expandafter #2\expandafter ##1\romannumeral-'0%
421         \csname XINT_#8_op_#3\endcsname {##4}}%
422     \else
423       \xint_afterfi
424       {\expandafter ##2\expandafter ##3%
425       \csname .=#6#9{\XINT_expr_unlock ##1}{\XINT_expr_unlock ##4}\endcsname }%
426     \fi
427   }%
428   \let #7#5%
429 }%
430 \def\XINT_tmpa #1{\XINT_tmpb {expr}{xint}#1{}}%
431 \xintApplyInline {\XINT_tmpa }{%
432   {|{iii}{vi}{OR}}%
433   {&{iv}{vi}{AND}}%
434   {<{v}{vi}{Lt}}%
435   {>{v}{vi}{Gt}}%
436   {={v}{vi}{Eq}}%
437   {+{vi}{vi}{Add}}%
438   {-{vi}{vi}{Sub}}%
439   {*{vii}{vii}{Mul}}%
440   {/{vii}{vii}{Div}}%
441   {^{\viii}{viii}{Pow}}%
442   {e{ix}{ix}{fE}}%
443   {E{ix}{ix}{fE}}%
444 }%
445 \def\XINT_tmpa #1{\XINT_tmpb {flexpr}{xint}#1{}}%
446 \xintApplyInline {\XINT_tmpa }{%
447   {|{iii}{vi}{OR}}%
448   {&{iv}{vi}{AND}}%
449   {<{v}{vi}{Lt}}%
450   {>{v}{vi}{Gt}}%
451   {={v}{vi}{Eq}}%
452 }%

```

```

453 \def\XINT_tmpa #1{\XINT_tmpb {flexpr}{XINTinFloat}#1{[\XINTdigits]}}%
454 \xintApplyInline {\XINT_tmpa }{%
455   {+{vi}{vi}{Add}}%
456   {-{vi}{vi}{Sub}}%
457   {*{vii}{vii}{Mul}}%
458   {/{vii}{vii}{Div}}%
459   {^{viii}{viii}{Power}}%
460   {e{ix}{ix}{fE}}%
461   {E{ix}{ix}{fE}}%
462 }%
463 \def\XINT_tmpa #1{\XINT_tmpb {iiexpr}{xint}#1{}}%
464 \xintApplyInline {\XINT_tmpa }{%
465   {|{iii}{vi}{OR}}%
466   {&{iv}{vi}{AND}}%
467   {<{v}{vi}{Lt}}%
468   {>{v}{vi}{Gt}}%
469   {={v}{vi}{Eq}}%
470   {+{vi}{vi}{iiAdd}}%
471   {-{vi}{vi}{iiSub}}%
472   {*{vii}{vii}{iiMul}}%
473   {/{vii}{vii}{iiQuo}}%
474   {^{viii}{viii}{iiPow}}%
475   {e{ix}{ix}{iE}}%
476   {E{ix}{ix}{iE}}%
477 }%

```

### 42.13 The comma as binary operator

New with 1.09a.

```

478 \def\XINT_tmpa #1#2#3#4#5#6%
479 {%
480   \def #1##1% \XINT_expr_op_,_a
481   {%
482     \expandafter #2\expandafter ##1\romannumeral-'0\XINT_expr_getnext
483   }%
484   \def #2##1##2% \XINT_expr_until_,_a
485   {\xint_UDsignfork
486     ##2{\expandafter #2\expandafter ##1\romannumeral-'0#4}%
487     -{#3##1##2}%
488   \krof }%
489   \def #3##1##2##3##4% \XINT_expr_until_,_b
490   {%
491     \ifnum ##2>\xint_c_ii
492       \xint_afterfi {\expandafter #2\expandafter ##1\romannumeral-'0%
493         \csname XINT_#6_op_##3\endcsname {##4}}%
494     \else
495       \xint_afterfi
496       {\expandafter ##2\expandafter ##3%

```

```

497     \csname .=\XINT_expr_unlock ##1,\XINT_expr_unlock ##4\endcsname }%
498     \fi
499 }%
500 \let #5\xint_c_ii
501 }%
502 \xintFor #1 in {expr,flexpr,iiexpr} \do {%
503 \expandafter\XINT_tmpa
504     \csname XINT_#1_op_,\expandafter\endcsname
505     \csname XINT_#1_until_,_a\expandafter\endcsname
506     \csname XINT_#1_until_,_b\expandafter\endcsname
507     \csname XINT_#1_op_-vi\expandafter\endcsname
508     \csname XINT_expr_precedence_,\endcsname {#1}%
509 }%

```

#### 42.14 \XINT\_expr\_op\_-<level>: minus as prefix inherits its precedence level

1.09i: \xintiexpr must use \xintiiOpp (or at least \xintiOpp, but that would be a waste; however impacts round and trunc as I allow them).

```

510 \def\XINT_tmpa #1#2#3%
511 {%
512     \expandafter\XINT_tmppb
513     \csname XINT_#1_op_-#3\expandafter\endcsname
514     \csname XINT_#1_until_-#3_a\expandafter\endcsname
515     \csname XINT_#1_until_-#3_b\expandafter\endcsname
516     \csname xint_c_#3\endcsname {#1}#2%
517 }%
518 \def\XINT_tmppb #1#2#3#4#5#6%
519 {%
520     \def #1% \XINT_expr_op_-<level>
521     {% get next number+operator then switch to _until macro
522         \expandafter #2\romannumeral-'0\XINT_expr_getnext
523     }%
524     \def #2##1% \XINT_expr_until_-<l>_a
525     {\xint_UDsignfork
526         ##1{\expandafter #2\romannumeral-'0#1}%
527         -{#3##1}%
528     \krof }%
529     \def #3##1##2##3% \XINT_expr_until_-<l>_b
530     {% _until tests precedence level with next op, executes now or postpones
531         \ifnum ##1>#4%
532             \xint_afterfi {\expandafter #2\romannumeral-'0%
533                 \csname XINT_#5_op_##2\endcsname {##3}}%
534         \else
535             \xint_afterfi {\expandafter ##1\expandafter ##2%
536                 \csname .=#6{\XINT_expr_unlock ##3}\endcsname }%
537         \fi
538     }%
539 }%

```

```

540 \xintApplyInline{\XINT_tmpa {expr}\xintOpp}{\vi}{vii}{viii}{ix}}%
541 \xintApplyInline{\XINT_tmpa {flexpr}\xintOpp}{\vi}{vii}{viii}{ix}}%
542 \xintApplyInline{\XINT_tmpa {iiexpr}\xintiiOpp}{\vi}{vii}{viii}{ix}}%

```

### 42.15 ? as two-way conditional

New with 1.09a. Modified in 1.09c to have less precedence than functions. Code is cleaner as it does not play tricks with `_precedence`. There is no associated `until` macro, because action is immediate once activated (only a previously scanned function can delay activation).

```

543 \let\XINT_expr_precedence_? \xint_c_x
544 \def \XINT_expr_op_? #1#2#3%
545 {%
546     \xintifZero{\XINT_expr_unlock #1}%
547     {\XINT_expr_getnext #3}%
548     {\XINT_expr_getnext #2}%
549 }%
550 \let\XINT_flexpr_op_?\XINT_expr_op_?
551 \let\XINT_iiexpr_op_?\XINT_expr_op_?

```

### 42.16 : as three-way conditional

New with 1.09a. Modified in 1.09c to have less precedence than functions.

```

552 \let\XINT_expr_precedence_: \xint_c_x
553 \def \XINT_expr_op_: #1#2#3#4%
554 {%
555     \xintifSgn {\XINT_expr_unlock #1}%
556     {\XINT_expr_getnext #2}%
557     {\XINT_expr_getnext #3}%
558     {\XINT_expr_getnext #4}%
559 }%
560 \let\XINT_flexpr_op_:\XINT_expr_op_:
561 \let\XINT_iiexpr_op_:\XINT_expr_op_:

```

### 42.17 ! as postfix factorial operator

The factorial is currently the exact one, there is no float version. Starting with 1.09c, it has lower priority than functions, it is not executed immediately anymore. The code is cleaner and does not abuse `_precedence`, but does assign it a true level. There is no `until` macro, because the factorial acts on what precedes it.

```

562 \let\XINT_expr_precedence_! \xint_c_x
563 \def\XINT_expr_op_! #1{\expandafter\XINT_expr_getop
564     \csname .=\xintFac{\XINT_expr_unlock #1}\endcsname }%
565 \let\XINT_flexpr_op_!\XINT_expr_op_!

```

```

566 \def\XINT_iiexpr_op_! #1{\expandafter\XINT_expr_getop
567     \csname .=\xintiFac{\XINT_expr_unlock #1}\endcsname }%

```

## 42.18 Functions

New with 1.09a. Names of ..Float...csv macros have been changed in 1.09h

```

568 \def\XINT_tmpa #1#2#3#4{%
569     \def #1##1%
570     {%
571         \ifcsname XINT_expr_onlitteral_##1\endcsname
572             \expandafter\XINT_expr_funcoflitteral
573         \else
574             \expandafter #2%
575         \fi {##1}%
576     }%
577 \def #2##1%
578     {%
579         \ifcsname XINT_#4_func_##1\endcsname
580         \xint_afterfi
581             {\expandafter\expandafter\csname XINT_#4_func_##1\endcsname}%
582         \else \csname xintError:unknown '##1\string'\endcsname
583             \xint_afterfi{\expandafter\XINT_expr_func_unknown}%
584         \fi
585         \romannumeral-'0#3%
586     }%
587 }%
588 \xintFor #1 in {expr,flexpr,iiexpr} \do {%
589     \expandafter\XINT_tmpa
590         \csname XINT_#1_op_@\expandafter\endcsname
591         \csname XINT_#1_op_@@\expandafter\endcsname
592         \csname XINT_#1_oparen\endcsname {#1}%
593 }%
594 \def\XINT_expr_funcoflitteral #1%
595 {%
596     \expandafter\expandafter\csname XINT_expr_onlitteral_#1\endcsname
597     \romannumeral-'0\XINT_expr_scanfunc
598 }%
599 \def\XINT_expr_onlitteral_bool #1#2#3{\expandafter\XINT_expr_getop
600     \csname .=\xintBool{#3}\endcsname }%
601 \def\XINT_expr_onlitteral_togl #1#2#3{\expandafter\XINT_expr_getop
602     \csname .=\xintToggle{#3}\endcsname }%
603 \def\XINT_expr_func_unknown #1#2#3% 1.09i removes [0], because \xintiexpr
604     {\expandafter #1\expandafter #2\csname .=\endcsname }%
605 \def\XINT_expr_func_reduce #1#2#3%
606 {%
607     \expandafter #1\expandafter #2\csname
608         .=\xintIrr {\XINT_expr_unlock #3}\endcsname
609 }%

```

```

610 \let\XINT_flexpr_func_reduce\XINT_expr_func_reduce
611 % \XINT_iiexpr_func_reduce not defined
612 \def\XINT_expr_func_frac #1#2#3%
613 {%
614   \expandafter #1\expandafter #2\csname
615     .=\xintTFrac {\XINT_expr_unlock #3}\endcsname
616 }%
617 \def\XINT_flexpr_func_frac #1#2#3%
618 {%
619   \expandafter #1\expandafter #2\csname
620     .=\XINTinFloatFrac [\XINTdigits]{\XINT_expr_unlock #3}\endcsname
621 }%
622 % \XINT_iiexpr_func_frac not defined
623 \def\XINT_expr_func_sqr #1#2#3%
624 {%
625   \expandafter #1\expandafter #2\csname
626     .=\xintSqr {\XINT_expr_unlock #3}\endcsname
627 }%
628 \def\XINT_flexpr_func_sqr #1#2#3%
629 {%
630   \expandafter #1\expandafter #2\csname
631     .=\XINTinFloatMul [\XINTdigits]%
632     {\XINT_expr_unlock #3}{\XINT_expr_unlock #3}\endcsname
633 }%
634 \def\XINT_iiexpr_func_sqr #1#2#3%
635 {%
636   \expandafter #1\expandafter #2\csname
637     .=\xintiiSqr {\XINT_expr_unlock #3}\endcsname
638 }%
639 \def\XINT_expr_func_abs #1#2#3%
640 {%
641   \expandafter #1\expandafter #2\csname
642     .=\xintAbs {\XINT_expr_unlock #3}\endcsname
643 }%
644 \let\XINT_flexpr_func_abs\XINT_expr_func_abs
645 \def\XINT_iiexpr_func_abs #1#2#3%
646 {%
647   \expandafter #1\expandafter #2\csname
648     .=\xintiiAbs {\XINT_expr_unlock #3}\endcsname
649 }%
650 \def\XINT_expr_func_sgn #1#2#3%
651 {%
652   \expandafter #1\expandafter #2\csname
653     .=\xintSgn {\XINT_expr_unlock #3}\endcsname
654 }%
655 \let\XINT_flexpr_func_sgn\XINT_expr_func_sgn
656 \def\XINT_iiexpr_func_sgn #1#2#3%
657 {%
658   \expandafter #1\expandafter #2\csname

```

```

659      .=\xintiiSgn {\XINT_expr_unlock #3}\endcsname
660 }%
661 \def\XINT_expr_func_floor #1#2#3%
662 {%
663   \expandafter #1\expandafter #2\csname
664     .=\xintFloor {\XINT_expr_unlock #3}\endcsname
665 }%
666 \let\XINT_flexpr_func_floor\XINT_expr_func_floor
667 \let\XINT_iiexpr_func_floor\XINT_expr_func_floor
668 \def\XINT_expr_func_ceil #1#2#3%
669 {%
670   \expandafter #1\expandafter #2\csname
671     .=\xintCeil {\XINT_expr_unlock #3}\endcsname
672 }%
673 \let\XINT_flexpr_func_ceil\XINT_expr_func_ceil
674 \let\XINT_iiexpr_func_ceil\XINT_expr_func_ceil
675 \def\XINT_expr_twoargs #1,#2,{\#1}{\#2}}%
676 \def\XINT_expr_func_quo #1#2#3%
677 {%
678   \expandafter #1\expandafter #2\csname .=%
679     \expandafter\expandafter\expandafter\xintQuo
680     \expandafter\XINT_expr_twoargs
681     \romannumeral-'0\XINT_expr_unlock #3,\endcsname
682 }%
683 \let\XINT_flexpr_func_quo\XINT_expr_func_quo
684 \def\XINT_iiexpr_func_quo #1#2#3%
685 {%
686   \expandafter #1\expandafter #2\csname .=%
687     \expandafter\expandafter\expandafter\xintiiQuo
688     \expandafter\XINT_expr_twoargs
689     \romannumeral-'0\XINT_expr_unlock #3,\endcsname
690 }%
691 \def\XINT_expr_func_rem #1#2#3%
692 {%
693   \expandafter #1\expandafter #2\csname .=%
694     \expandafter\expandafter\expandafter\xintRem
695     \expandafter\XINT_expr_twoargs
696     \romannumeral-'0\XINT_expr_unlock #3,\endcsname
697 }%
698 \let\XINT_flexpr_func_rem\XINT_expr_func_rem
699 \def\XINT_iiexpr_func_rem #1#2#3%
700 {%
701   \expandafter #1\expandafter #2\csname .=%
702     \expandafter\expandafter\expandafter\xintiiRem
703     \expandafter\XINT_expr_twoargs
704     \romannumeral-'0\XINT_expr_unlock #3,\endcsname
705 }%
706 \def\XINT_expr_oneortwo #1#2#3,#4,#5.%
707 {%

```

```

708 \if\relax#5\relax\expandafter\xint_firstoftwo\else
709 \expandafter\xint_secondoftwo\fi
710 {#1{0}}{#2{\xintNum {#4}}}{#3}%
711 }%
712 \def\xINT_expr_func_round #1#2#3%
713 {%
714 \expandafter #1\expandafter #2\csname .=%
715 \expandafter\xINT_expr_oneortwo
716 \expandafter\xintiRound\expandafter\xintRound
717 \romannumeral-‘0\xINT_expr_unlock #3,,.\endcsname
718 }%
719 \let\xINT_flexpr_func_round\xINT_expr_func_round
720 \def\xINT_iiexpr_oneortwo #1#2,#3,#4.%
721 {%
722 \if\relax#4\relax\expandafter\xint_firstoftwo\else
723 \expandafter\xint_secondoftwo\fi
724 {#1{0}}{#1{#3}}{#2}%
725 }%
726 \def\xINT_iiexpr_func_round #1#2#3%
727 {%
728 \expandafter #1\expandafter #2\csname .=%
729 \expandafter\xINT_iiexpr_oneortwo\expandafter\xintiRound
730 \romannumeral-‘0\xINT_expr_unlock #3,,.\endcsname
731 }%
732 \def\xINT_expr_func_trunc #1#2#3%
733 {%
734 \expandafter #1\expandafter #2\csname .=%
735 \expandafter\xINT_expr_oneortwo
736 \expandafter\xintiTrunc\expandafter\xintTrunc
737 \romannumeral-‘0\xINT_expr_unlock #3,,.\endcsname
738 }%
739 \let\xINT_flexpr_func_trunc\xINT_expr_func_trunc
740 \def\xINT_iiexpr_func_trunc #1#2#3%
741 {%
742 \expandafter #1\expandafter #2\csname .=%
743 \expandafter\xINT_iiexpr_oneortwo\expandafter\xintiTrunc
744 \romannumeral-‘0\xINT_expr_unlock #3,,.\endcsname
745 }%
746 \def\xINT_expr_argandopt #1,#2,#3.%
747 {%
748 \if\relax#3\relax\expandafter\xint_firstoftwo\else
749 \expandafter\xint_secondoftwo\fi
750 {[\xINTdigits]][\xintNum {#2}]{#1}%
751 }%
752 \def\xINT_expr_func_float #1#2#3%
753 {%
754 \expandafter #1\expandafter #2\csname .=%
755 \expandafter\xINTinFloat
756 \romannumeral-‘0\expandafter\xINT_expr_argandopt

```

```

757 \romannumeral-‘0\XINT_expr_unlock #3,,.\endcsname
758 }%
759 \let\XINT_flexpr_func_float\XINT_expr_func_float
760 % \XINT_iiexpr_func_float not defined
761 \def\XINT_expr_func_sqrt #1#2#3%
762 {%
763 \expandafter #1\expandafter #2\csname .=%
764 \expandafter\XINTinFloatSqrt
765 \romannumeral-‘0\expandafter\XINT_expr_argandopt
766 \romannumeral-‘0\XINT_expr_unlock #3,,.\endcsname
767 }%
768 \let\XINT_flexpr_func_sqrt\XINT_expr_func_sqrt
769 \def\XINT_iiexpr_func_sqrt #1#2#3%
770 {%
771 \expandafter #1\expandafter #2\csname
772 .=\xintiSqrt {\XINT_expr_unlock #3}\endcsname
773 }%
774 \def\XINT_expr_func_gcd #1#2#3%
775 {%
776 \expandafter #1\expandafter #2\csname
777 .=\xintGCDof:csv{\XINT_expr_unlock #3}\endcsname
778 }%
779 \let\XINT_flexpr_func_gcd\XINT_expr_func_gcd
780 \let\XINT_iiexpr_func_gcd\XINT_expr_func_gcd
781 \def\XINT_expr_func_lcm #1#2#3%
782 {%
783 \expandafter #1\expandafter #2\csname
784 .=\xintLCMof:csv{\XINT_expr_unlock #3}\endcsname
785 }%
786 \let\XINT_flexpr_func_lcm\XINT_expr_func_lcm
787 \let\XINT_iiexpr_func_lcm\XINT_expr_func_lcm
788 \def\XINT_expr_func_max #1#2#3%
789 {%
790 \expandafter #1\expandafter #2\csname
791 .=\xintMaxof:csv{\XINT_expr_unlock #3}\endcsname
792 }%
793 \def\XINT_iiexpr_func_max #1#2#3%
794 {%
795 \expandafter #1\expandafter #2\csname
796 .=\xintiMaxof:csv{\XINT_expr_unlock #3}\endcsname
797 }%
798 \def\XINT_flexpr_func_max #1#2#3%
799 {%
800 \expandafter #1\expandafter #2\csname
801 .=\XINTinFloatMaxof:csv{\XINT_expr_unlock #3}\endcsname
802 }%
803 \def\XINT_expr_func_min #1#2#3%
804 {%
805 \expandafter #1\expandafter #2\csname

```

```

806      .=\xintMinof:csv{\XINT_expr_unlock #3}\endcsname
807 }%
808 \def\XINT_iiexpr_func_min #1#2#3%
809 {%
810   \expandafter #1\expandafter #2\csname
811     .=\xintiMinof:csv{\XINT_expr_unlock #3}\endcsname
812 }%
813 \def\XINT_flexpr_func_min #1#2#3%
814 {%
815   \expandafter #1\expandafter #2\csname
816     .=\XINTinFloatMinof:csv{\XINT_expr_unlock #3}\endcsname
817 }%
818 \def\XINT_expr_func_sum #1#2#3%
819 {%
820   \expandafter #1\expandafter #2\csname
821     .=\xintSum:csv{\XINT_expr_unlock #3}\endcsname
822 }%
823 \def\XINT_flexpr_func_sum #1#2#3%
824 {%
825   \expandafter #1\expandafter #2\csname
826     .=\XINTinFloatSum:csv{\XINT_expr_unlock #3}\endcsname
827 }%
828 \def\XINT_iiexpr_func_sum #1#2#3%
829 {%
830   \expandafter #1\expandafter #2\csname
831     .=\xintiiSum:csv{\XINT_expr_unlock #3}\endcsname
832 }%
833 \def\XINT_expr_func_prd #1#2#3%
834 {%
835   \expandafter #1\expandafter #2\csname
836     .=\xintPrd:csv{\XINT_expr_unlock #3}\endcsname
837 }%
838 \def\XINT_flexpr_func_prd #1#2#3%
839 {%
840   \expandafter #1\expandafter #2\csname
841     .=\XINTinFloatPrd:csv{\XINT_expr_unlock #3}\endcsname
842 }%
843 \def\XINT_iiexpr_func_prd #1#2#3%
844 {%
845   \expandafter #1\expandafter #2\csname
846     .=\xintiiPrd:csv{\XINT_expr_unlock #3}\endcsname
847 }%
848 \let\XINT_expr_func_add\XINT_expr_func_sum
849 \let\XINT_expr_func_mul\XINT_expr_func_prd
850 \let\XINT_flexpr_func_add\XINT_flexpr_func_sum
851 \let\XINT_flexpr_func_mul\XINT_flexpr_func_prd
852 \let\XINT_iiexpr_func_add\XINT_iiexpr_func_sum
853 \let\XINT_iiexpr_func_mul\XINT_iiexpr_func_prd
854 \def\XINT_expr_func_? #1#2#3%

```

```

855 {%
856   \expandafter #1\expandafter #2\csname
857     .=\xintIsNotZero {\XINT_expr_unlock #3}\endcsname
858 }%
859 \let\XINT_flexpr_func_? \XINT_expr_func_?
860 \let\XINT_iexpr_func_? \XINT_expr_func_?
861 \def\XINT_expr_func_! #1#2#3%
862 {%
863   \expandafter #1\expandafter #2\csname
864     .=\xintIsZero {\XINT_expr_unlock #3}\endcsname
865 }%
866 \let\XINT_flexpr_func_! \XINT_expr_func_!
867 \let\XINT_iexpr_func_! \XINT_expr_func_!
868 \def\XINT_expr_func_not #1#2#3%
869 {%
870   \expandafter #1\expandafter #2\csname
871     .=\xintIsZero {\XINT_expr_unlock #3}\endcsname
872 }%
873 \let\XINT_flexpr_func_not \XINT_expr_func_not
874 \let\XINT_iexpr_func_not \XINT_expr_func_not
875 \def\XINT_expr_func_all #1#2#3%
876 {%
877   \expandafter #1\expandafter #2\csname
878     .=\xintANDof:csv{\XINT_expr_unlock #3}\endcsname
879 }%
880 \let\XINT_flexpr_func_all\XINT_expr_func_all
881 \let\XINT_iexpr_func_all\XINT_expr_func_all
882 \def\XINT_expr_func_any #1#2#3%
883 {%
884   \expandafter #1\expandafter #2\csname
885     .=\xintORof:csv{\XINT_expr_unlock #3}\endcsname
886 }%
887 \let\XINT_flexpr_func_any\XINT_expr_func_any
888 \let\XINT_iexpr_func_any\XINT_expr_func_any
889 \def\XINT_expr_func_xor #1#2#3%
890 {%
891   \expandafter #1\expandafter #2\csname
892     .=\xintXORof:csv{\XINT_expr_unlock #3}\endcsname
893 }%
894 \let\XINT_flexpr_func_xor\XINT_expr_func_xor
895 \let\XINT_iexpr_func_xor\XINT_expr_func_xor
896 \def\xintifNotZero:: #1,#2,#3,{\xintifNotZero{#1}{#2}{#3}}%
897 \def\XINT_expr_func_if #1#2#3%
898 {%
899   \expandafter #1\expandafter #2\csname
900     .=\expandafter\xintifNotZero::
901       \romannumeral-'0\XINT_expr_unlock #3,\endcsname
902 }%
903 \let\XINT_flexpr_func_if\XINT_expr_func_if

```

```

904 \let\XINT_iiexpr_func_if\XINT_expr_func_if
905 \def\xintifSgn:: #1,#2,#3,#4,{\xintifSgn{#1}{#2}{#3}{#4}}%
906 \def\XINT_expr_func_ifsgn #1#2#3%
907 {%
908   \expandafter #1\expandafter #2\csname
909     .=\expandafter\xintifSgn::
910       \romannumeral-'0\XINT_expr_unlock #3,\endcsname
911 }%
912 \let\XINT_flexpr_func_ifsgn\XINT_expr_func_ifsgn
913 \let\XINT_iiexpr_func_ifsgn\XINT_expr_func_ifsgn

```

### 42.19 \xintNewExpr, \xintNewFloatExpr...

Rewritten in 1.09a. Now, the parameters of the formula are entered in the usual way by the user, with # not \_. And \_ is assigned to make macros not expand. This way, : is freed, as we now need it for the ternary operator. (on numeric data; if use with macro parameters, should be coded with the functionn ifsgn , rather)

Code unified in 1.09c, and \xintNewNumExpr, \xintNewBoolExpr added. 1.09i re-names \xintNewNumExpr to \xintNewIExpr, and defines \xintNewIIExpr.

```

914 \def\XINT_newexpr_print #1{\ifnum\xintNthElt{0}{#1}>1
915   \expandafter\xint_firstoftwo
916   \else
917   \expandafter\xint_secondoftwo
918   \fi
919   {_xintListWithSep,{#1}}{\xint_firstofone#1}}%
920 \xintForpair #1#2 in {(fl,Float),(i,iRound0),(bool,IsTrue)}\do {%
921   \expandafter\def\csname XINT_new#1expr_print\endcsname
922     ##1{\ifnum\xintNthElt{0}{##1}>1
923       \expandafter\xint_firstoftwo
924       \else
925       \expandafter\xint_secondoftwo
926       \fi
927       {_xintListWithSep,{\xintApply{\xint#2}{##1}}}
928       {_xint#2##1}}}%
929 \toks0 {}%
930 \xintFor #1 in {Bool,Toggle,Floor,Ceil,iRound,Round,iTrunc,Trunc,TFrac,%
931   Lt,Gt,Eq,AND,OR,IsNotZero,IsZero,ifNotZero,ifSgn,%
932   Irr,Num,Abs,Sgn,Opp,Quo,Rem,Add,Sub,Mul,Sqr,Div,Pow,Fac,fE,iSqrt,%
933   iiAdd,iiSub,iiMul,iiSqr,iiPow,iiQuo,iiRem,iiSgn,iiAbs,iiOpp,iE}\do
934 {\toks0
935   \expandafter{\the\toks0\expandafter\def\csname xint#1\endcsname {_xint#1}}}%
936 \xintFor #1 in {,Sqrt,Add,Sub,Mul,Div,Power,fE,Frac}\do
937 {\toks0
938   \expandafter{\the\toks0\expandafter\def\csname XINTinFloat#1\endcsname
939     {_XINTinFloat#1}}}%
940 \xintFor #1 in {GCDof,LCMof,Maxof,Minof,ANDof,ORof,XORof,Sum,Prd,%
941   iMaxof,iMinof,iiSum,iiPrd}\do
942 {\toks0

```

```

943 \expandafter{\the\toks0\expandafter\def\csname xint#1:csv\endcsname
944     #####1{ _xint#1{\xintCSVtoListNonStripped {#####1}}}}}%
945 \xintFor #1 in {Maxof,Minof,Sum,Prd}\do
946 {\toks0
947 \expandafter{\the\toks0\expandafter\def\csname XINTinFloat#1:csv\endcsname
948     #####1{ _XINTinFloat#1{\xintCSVtoListNonStripped {#####1}}}}}%
949 \expandafter\def\expandafter\XINT_expr_protect\expandafter{\the\toks0
950     \def\XINTdigits {_XINTdigits}%
951     \def\XINT_expr_print ##1{\expandafter\XINT_newexpr_print\expandafter
952         {\romannumeral0\xintcsvtoListnonstripped{\XINT_expr_unlock ##1}}}%
953     \def\XINT_flexpr_print ##1{\expandafter\XINT_newflexpr_print\expandafter
954         {\romannumeral0\xintcsvtoListnonstripped{\XINT_expr_unlock ##1}}}%
955     \def\XINT_iexpr_print ##1{\expandafter\XINT_newiexpr_print\expandafter
956         {\romannumeral0\xintcsvtoListnonstripped{\XINT_expr_unlock ##1}}}%
957     \def\XINT_boolexpr_print ##1{\expandafter\XINT_newboolexpr_print\expandafter
958         {\romannumeral0\xintcsvtoListnonstripped{\XINT_expr_unlock ##1}}}%
959 }%
960 \toks0 {}%
961 \def\xintNewExpr {\xint_NewExpr\xinttheexpr }%
962 \def\xintNewFloatExpr {\xint_NewExpr\xintthefloatexpr }%
963 \def\xintNewIExpr {\xint_NewExpr\xinttheiexpr }%
964 \let\xintNewNumExpr\xintNewIExpr
965 \def\xintNewIIExpr {\xint_NewExpr\xinttheiiexpr }%
966 \def\xintNewBoolExpr {\xint_NewExpr\xinttheboolexpr }%

1.09i has added \escapechar 92, as \meaning is used in \XINT_NewExpr, and a non
existent escape-char would be a problem with \scantokens. Also \catcode32 is set
to 10 in \xintexprSafeCatcodes for being extra-safe.

967 \def\xint_NewExpr #1#2[#3]%
968 {%
969 \begingroup
970 \ifcase #3\relax
971     \toks0 {\xdef #2}%
972 \or \toks0 {\xdef #2##1}%
973 \or \toks0 {\xdef #2##1##2}%
974 \or \toks0 {\xdef #2##1##2##3}%
975 \or \toks0 {\xdef #2##1##2##3##4}%
976 \or \toks0 {\xdef #2##1##2##3##4##5}%
977 \or \toks0 {\xdef #2##1##2##3##4##5##6}%
978 \or \toks0 {\xdef #2##1##2##3##4##5##6##7}%
979 \or \toks0 {\xdef #2##1##2##3##4##5##6##7##8}%
980 \or \toks0 {\xdef #2##1##2##3##4##5##6##7##8##9}%
981 \fi
982 \xintexprSafeCatcodes
983 \escapechar92
984 \XINT_NewExpr #1%
985 }%
986 \catcode'* 13
987 \def\XINT_NewExpr #1#2%

```

```

988 {%
989   \def\XINT_tmpa ##1##2##3##4##5##6##7##8##9{#2}%
990   \XINT_expr_protect
991   \lccode'*= '_ \lowercase {\def*}{!noexpand!}%
992   \catcode'_ 13 \catcode': 11 %\endlinechar -1 %not sure why I had that, \par?
993   \everyeof {\noexpand}%
994   \edef\XINT_tmpb ##1##2##3##4##5##6##7##8##9%
995     {\scantokens
996       \expandafter{\romannumeral-'0#1%
997         \XINT_tmpa {####1}{####2}{####3}%
998           {####4}{####5}{####6}%
999             {####7}{####8}{####9}%
1000               \relax}}%
1001   \lccode'*= '\$ \lowercase {\def*}{####}%
1002   \catcode'\$ 13 \catcode'! 0 \catcode'_ 11 %
1003   \the\toks0
1004   {\scantokens\expandafter{\expandafter
1005     \XINT_newexpr_setprefix\meaning\XINT_tmpb}}%
1006 \endgroup
1007}%
1008\let\xintexprRestoreCatcodes\empty
1009\def\xintexprSafeCatcodes
1010{% for end user.
1011  \edef\xintexprRestoreCatcodes {%
1012    \catcode63=\the\catcode63 % ?
1013    \catcode124=\the\catcode124 % |
1014    \catcode38=\the\catcode38 % &
1015    \catcode33=\the\catcode33 % !
1016    \catcode93=\the\catcode93 % ]
1017    \catcode91=\the\catcode91 % [
1018    \catcode94=\the\catcode94 % ^
1019    \catcode95=\the\catcode95 % _
1020    \catcode47=\the\catcode47 % /
1021    \catcode41=\the\catcode41 % )
1022    \catcode40=\the\catcode40 % (
1023    \catcode42=\the\catcode42 % *
1024    \catcode43=\the\catcode43 % +
1025    \catcode62=\the\catcode62 % >
1026    \catcode60=\the\catcode60 % <
1027    \catcode58=\the\catcode58 % :
1028    \catcode46=\the\catcode46 % .
1029    \catcode45=\the\catcode45 % -
1030    \catcode44=\the\catcode44 % ,
1031    \catcode61=\the\catcode61 % =
1032    \catcode32=\the\catcode32\relax % space
1033  }% it's hard to know where to stop...
1034    \catcode63=12 % ?
1035    \catcode124=12 % |
1036    \catcode38=4 % &

```

```

1037      \catcode33=12 % !
1038      \catcode93=12 % ]
1039      \catcode91=12 % [
1040      \catcode94=7  % ^
1041      \catcode95=8  % _
1042      \catcode47=12 % /
1043      \catcode41=12 % )
1044      \catcode40=12 % (
1045      \catcode42=12 % *
1046      \catcode43=12 % +
1047      \catcode62=12 % >
1048      \catcode60=12 % <
1049      \catcode58=12 % :
1050      \catcode46=12 % .
1051      \catcode45=12 % -
1052      \catcode44=12 % ,
1053      \catcode61=12 % =
1054      \catcode32=10 % space
1055 }%
1056 \let\XINT_tmpa\relax \let\XINT_tmpb\relax \let\XINT_tmpc\relax
1057 \XINT_restorecatcodes_endinput%

```

xinttools: 1051. Total number of code lines: 10664. Each package starts with  
   xint: 3515. circa 80 lines dealing with catcodes, package identification and  
 xintbinhex: 640. reloading management, also for Plain  $\text{\TeX}$ . Version 1.09j of  
   xintgcd: 463. 2014/01/09.  
   xintfrac: 2577.  
 xintseries: 417.  
   xintcfrac: 944.  
   xintexpr: 1057.