Actuarial symbols of life contingencies and financial mathematics *

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Abstract

Package actuarialsymbol provides facilities to compose actuarial symbols of life contingencies and financial mathematics characterized by subscripts and superscripts on both sides of a principal symbol. The package also features commands to easily and consistently position precedence numbers above or below statuses in symbols for multiple lives contracts.

Since the actuarial notation can get quite involved. the package defines a number of shortcut macros to ease entry of the most common elements. Appendix A lists the commands to typeset a large selection of symbols of life contingencies.

Contents

*This document corresponds to actuarialsymbol v1.0, dated 2017/04/11.

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1 Introduction

Actuaries denote various quantities of life contingencies like present values of life insurances and life annuities, annual premiums, or reserves using a whole array of symbols. The highly descriptive, yet compact, notation was standardized as far back as in 1898 (Wolthuis, 2004). Figure 1 shows a creative use of the notation by the graduating class of 1972 in Actuarial Science at Université Laval.

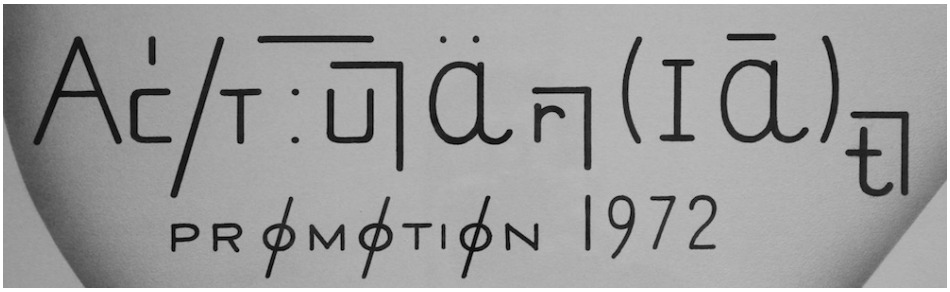

Figure 1: "Actuariat" (French for Actuarial Science) written using actuarial symbols on the 1972 graduating class mosaic at Université Laval

Bowers et al. (1997, Appendix 4) offer an excellent overview of the composition rules for symbols of actuarial functions. In a nutshell, a principal symbol, say S, is combined with auxiliary symbols positioned in subscript or in superscript, to the left or to the right. Schematically, we thus have:

$$\begin{matrix}\boxed{\text{II}} & & \boxed{\text{IV}} \\ & S & \\ \boxed{\text{I}} & & \boxed{\text{III}}\end{matrix} \tag{1}$$

The principal symbol is in general a single letter. The letter may be "accented" with a bar ($\bar{A}$), double dots ($\ddot{a}$) or a circle ($\mathring{e}$). When the principal symbol consists of two letters, they are grouped between parentheses, as in (IA) or $(D\bar{A})$. Most commonly, there are alphanumeric statuses in the lower-right position $\boxed{\text{III}}$. Numerals can be placed above or below the individual statuses to show the order of failure; we will refer to these numerals as *precedence numbers*. Otherwise, auxiliary symbols appear lower-left $\boxed{\text{I}}$, upper-left $\boxed{\text{II}}$ and upper-right $\boxed{\text{IV}}$, in that order of frequency.

Principle symbols for benefit premiums, reserves and amount of reduced paid-up insurance, P, V and W, are combined with benefit symbols unless the benefit is a level unit insurance payable at the end of the year of death. In such cases, we have the following symbol structure (replace P by V or W as needed):

$$\begin{matrix}\boxed{\text{II}} & & \boxed{\text{IV}} & & \\ & P & & \left(\begin{matrix} & S & \\ & & \boxed{\text{III}}\end{matrix}\right) & \\ \boxed{\text{I}} & & & & \end{matrix} \tag{2}$$

Perhaps the most commonly used auxiliary symbol not readily available in LaTeX is the "angle" denoting a duration n, as in $\overline{n}|$. Package actuarialangle (Goulet, 2017) provides commands to create this symbol, as

well as an overhead angle bracket[1] (or "roof") used to emphasize joint status when ambiguity is possible: $\overset{\frown}{xy}$. This package is imported at load time by actuarialsymbol.

Package actuarialsymbol provides a generic command to position all subscripts and superscripts easily and consistently around a principal symbol, a command to create two-letter symbols and two commands to position precedence numbers above and below statuses. Since entering actuarial symbols can get quite involved, the package also defines a number of shortcuts to create the most common actuarial functions of financial mathematics and life contingencies.

2 For the impatient

The hurried reader may jump to section 4 for the shortcut macros defined by the package, and to Appendix A for a comprehensive list of symbols of life contingencies along with the LaTeX code to compose them with actuarialsymbol loaded. That said, in our highly biased view, it remains worth reading along the fine documentation below.

3 Package features

This section describes the generic commands provided by the package to compose actuarial symbols. On a daily basis, one should use the shortcuts of section 4 to ease entry of symbols.

3.1 Actuarial symbol

`\actsymb` The generic command `\actsymb` typesets a principal symbol with surrounding subscripts and superscripts. Its syntax is somewhat unusual for LaTeX, but it serves well the natural order of the building blocks of a symbol and their relative prevalence:

`\actsymb[`⟨*ll*⟩`][`⟨*ul*⟩`]{`⟨*symbol*⟩`}{`⟨*lr*⟩`}[`⟨*ur*⟩`]`

Above, ⟨*ll*⟩ identifies the auxiliary symbol in the lower left subscript position $\boxed{\text{I}}$ (following the notation in the schematic representation (1)); ⟨*ul*⟩ is the upper left superscript $\boxed{\text{II}}$; ⟨*symbol*⟩ is the principal symbol S; ⟨*lr*⟩ is the lower right subscript $\boxed{\text{III}}$; ⟨*ur*⟩ is the upper right superscript

[1] Starting with version 2.0 dated 2017/04/10.

IV. The principal symbol and the right subscript are required, the other arguments are optional.

`\actsymb{A}{x}`	A_x
`\actsymb[n]{A}{x}`	${}_{n}A_x$
`\actsymb[n][2]{A}{x}`	${}^{2}_{n}A_x$
`\actsymb[n][2]{A}{x}[(m)]`	${}^{2}_{n}A_x^{(m)}$

The command actually admits one more optional argument to compose symbols for premiums, reserves and paid-up insurance. The extended command

`\actsymb[`⟨*ll*⟩`][`⟨*ul*⟩`][`⟨*principle*⟩`]{`⟨*symbol*⟩`}{`⟨*lr*⟩`}[`⟨*ur*⟩`]`

puts symbol ⟨*principle*⟩ outside the parentheses in the schematic representation (2).

`\actsymb[][][P]{\bar{A}}{x:\angln}`	$P(\bar{A}_{x:\overline{n}\rceil})$
`\actsymb[k][][V]{\bar{A}}{x}[\{1\}]`	${}_{k}V^{\{1\}}(\bar{A}_x)$
`\actsymb[k][][\bar{W}]{\bar{A}}{x}`	${}_{k}\bar{W}(\bar{A}_x)$

Remark. TEX adjusts the position of a subscript downward when a superscript is present:

$$A_x \quad A_x^2.$$

The package maintains this behaviour. Therefore, entering the symbols above using the standard operators `^` and `_` or with `\actsymb` yields the same result.

`A_x \quad A_x^2`	$A_x \quad A_x^2$
`\actsymb{A}{x} \quad \actsymb{A}{x}[2]`	$A_x \quad A_x^2$

Furthermore, the package also ensures that the left and right subscripts, when both present, are at the same level, something popular ad hoc constructions do not provide.

`{}_tA_x \quad {}_tA_x^2`	${}_{t}A_x \quad {}_{t}A_x^2$
`\actsymb[t]{A}{x} \quad \actsymb[t]{A}{x}[2]`	${}_{t}A_x \quad {}_{t}A_x^2$

In symbols for premiums, reserves and paid-up insurance, subscripts and superscripts are aligned only around the principle symbol. Authors who would prefer a uniform subscript position *throughout their document* should load package subdepth (Robertson, 2007).

3.2 Two-letter principal symbols

\twoletsymb Entering two-letter principal symbols like (DA) as `$(DA)$` results in letters that are too distant from one another: (DA). To unify presentation, the package provides the command

\twoletsymb[⟨*length*⟩]{⟨*symbol_1*⟩}{⟨*symbol_2*⟩}

to group ⟨*symbol_1*⟩ and ⟨*symbol_2*⟩ between parentheses with kerning[2] reduced by length \twoletkern (see below). One can also reduce spacing by ⟨*length*⟩ for a specific symbol.

`\twoletsymb{\bar{D}}{\bar{A}}`	$(\bar{D}\bar{A})$
`\twoletsymb{I}{\ddot{a}}`	$(I\ddot{a})$
`\twoletsymb[0.8pt]{I}{\ddot{a}}`	$(I\ddot{a})$

We expect authors to use \twoletsymb to define commands, not directly in equations. The package already defines a number of shortcuts for the main two-letter actuarial symbols; see section 4.

\twoletkern The standard kerning between mathematical symbols defined with \twoletsymb is *reduced* by the length \twoletkern, by default 1.2pt. This value can be changed as usual using \setlength.

3.3 Precedence numbers

\nthtop \nthtop* Precedence numbers appear above or below individual statuses in the right subscript $\boxed{\text{III}}$ of a symbol. Commands

\nthtop[⟨*length*⟩]{⟨*number*⟩}{⟨*status*⟩}
\nthtop*[⟨*length*⟩]{⟨*number*⟩}{⟨*status*⟩}

put a precedence ⟨*number*⟩ above a ⟨*status*⟩, smashed so that the apparent height of the status is its normal height. This is normally used in the right subscript $\boxed{\text{III}}$ of a symbol. With \nthtop, the spacing between the precedence number and the status is a constant \nthtopsep (see below). This can result in precedence numbers placed at different heights if one status contains an horizontal rule.

`\actsymb{A}{\nthtop{1}{x}:\angln}`	$A^{1}_{x:\overline{n}\vert}$
`\actsymb{A}{x:\nthtop{1}{\angln}}`	$A_{x:\overline{n}\vert}^{1}$
`\actsymb{A}{\nthtop{1}{x}y:\nthtop{2}{\angln}}`	$A^{1\ 2}_{xy:\overline{n}\vert}$

[2] Spacing adjustment between the characters

Conversely, `\nthtop*` always leaves enough space `\nthtopskip` for intervening horizontal rules, resulting in vertically aligned precedence numbers.

```
\actsymb{A}{\nthtop*{1}{x}:\angln}
\actsymb{A}{x:\nthtop*{1}{\angln}}
\actsymb{A}{\nthtop*{1}{x}y:\nthtop*{2}{\angln}}
```

$A^{1}_{x:\overline{n}|}$
$A_{x:\overline{1}|}$
$A^{1}_{xy:\overline{2}|}$

The optional argument ⟨*length*⟩ changes the default spacing for one symbol. The package also defines shortcuts for first, second and third top precedence; see section 4.

`\nthbottom`
`\nthbottom*`

In the same vein as the above two commands,

`\nthbottom[`⟨*length*⟩`]{`⟨*number*⟩`}{`⟨*status*⟩`}`
`\nthbottom*[`⟨*length*⟩`]{`⟨*number*⟩`}{`⟨*status*⟩`}`

put a precedence ⟨*number*⟩ below a ⟨*status*⟩. With `\nthbottom` the spacing between the status and the number is a constant `\nthbottomsep`, whereas with `\nthbottom*` enough spacing `\nthbottomskip` is left to bottom align the precedence numbers. The `*` variant is most useful in cases involving more than one bottom precedence numbers and statuses with descenders.

```
\actsymb{A}{\nthtop{3}{x}%
            \nthbottom{1}{y}\nthbottom{2}{z}}
\actsymb{A}{\nthtop{3}{x}%
            \nthbottom*{1}{y}\nthbottom*{2}{z}}
```

$A^{3}_{\substack{xyz\\ 12}}$
$A^{3}_{\substack{xyz\\ 12}}$

The optional argument ⟨*length*⟩ changes the default spacing for one symbol. The package also defines shortcuts for first, second and third bottom precedence; see section 4.

Remark. The fact that top precedence numbers have zero height means they will clash with a right superscript IV:

```
\actsymb{A}{\nthtop{1}{x}:\angln}[(m)]
```

$A^{(m)}_{x:\overline{n}|}$

In such rare circumstances, one needs to insert a *strut* (an invisible vertical rule) in the subscript to push it downward as needed:

```
\actsymb{A}{\rule{0pt}{2.3ex}%
            \nthtop{1}{x}:\angln}[(m)]
```

$A^{(m)}_{\substack{1\\ x:\overline{n}|}}$

This remark also applies to bottom precedence numbers in inline formulas or multiline equations.

\nthtopsep
\nthtopskip
\nthbottomsep
\nthbottomskip

The constant spacing between a top precedence number and the status underneath when using \nthtop is \nthtopsep, by default 2.0pt. The constant height of top precedence numbers when using \nthtop* is achieved by setting the baseline skip to \nthtopskip, by default 7.0pt.

Similarly, the constant spacing between a bottom precedence number and the status above when using \nthbottom is \nthbottomsep, by default 2.0pt, and the constant height of bottom precedence numbers when using \nthbottom* is achieved by setting the baseline skip to \nthbottomskip, by default 9.0pt.

These values can be changed as usual using \setlength.

4 Shortcuts

Composing actuarial symbols from scratch using \actsymb can easily get quite involved. For this reason, the package defines a large number of shortcut macros to ease entry of the most common symbols. We encourage authors to define their own shortcuts for cases we did not consider. The package provides powerful facilities to define shortcuts.

4.1 Basic symbols of life tables, insurance and annuities

Table 1 lists shortcuts to compose complete symbols of life tables and benefits of insurance and annuities. For space considerations only the mandatory arguments are given, but it should be noted that all commands of Table 1 accept the optional arguments ⟨*ll*⟩, ⟨*ul*⟩ and ⟨*ur*⟩ of \actsymb.

One will note that shortcuts for insurance benefits come in two variants: one for the benefit payable at the end of the year of death (standard shortcut) and one for the benefit payable at the time of death (* variant). Shortcuts for annuity benefits have three variants: payable at the end of the period (standard), continuously (* variant) and at the beginning of the period (** variant).

\@actinssc
\@actannsc
\@actothersc

One may define additional shortcut macros similar to those of Table 1 using the internal commands

\@actinssc{⟨*symbol*⟩}
\@actannsc{⟨*symbol*⟩}
\@actothersc{⟨*symbol*⟩}

Table 1: Shortcuts for life table, insurance and annuity symbols. All commands accept the optional arguments ⟨*ll*⟩, ⟨*ul*⟩ and ⟨*ur*⟩ of `\actsymb`.

Definition	Example	Output
`\lx{`⟨*age*⟩`}`	`\lx{x}`	ℓ_x
`\Lx{`⟨*age*⟩`}`	`\Lx{x}`	$\mathscr{L}_x{}^{\dagger}$
`\dx{`⟨*age*⟩`}`	`\dx[n]{x}`	${}_nd_x$
`\Dx{`⟨*age*⟩`}`	`\Dx[n]{x}`	${}_n\mathscr{D}_x{}^{\dagger}$
`\px{`⟨*age*⟩`}`	`\px[t]{x}`	${}_tp_x$
`\qx{`⟨*age*⟩`}`	`\qx[t]{x}`	${}_tq_x$
`\eringx{`⟨*lr*⟩`}`	`\eringx{x:\angln}`	$\mathring{e}_{x:\overline{n}\vert}$
`\Ax{`⟨*lr*⟩`}`	`\Ax{x:\angln}`	$A_{x:\overline{n}\vert}$
`\Ax*{`⟨*lr*⟩`}`	`\Ax*{x:\angln}`	$\bar{A}_{x:\overline{n}\vert}$
`\Ex{`⟨*lr*⟩`}`	`\Ex[n]{x}`	${}_nE_x$
`\ax{`⟨*lr*⟩`}`	`\ax{x:\angln}`	$a_{x:\overline{n}\vert}$
`\ax*{`⟨*lr*⟩`}`	`\ax*{x:\angln}`	$\bar{a}_{x:\overline{n}\vert}$
`\ax**{`⟨*lr*⟩`}`	`\ax**{x:\angln}`	$\ddot{a}_{x:\overline{n}\vert}$
`\sx{`⟨*lr*⟩`}`	`\sx{x:\angln}`	$s_{x:\overline{n}\vert}$
`\sx*{`⟨*lr*⟩`}`	`\sx*{x:\angln}`	$\bar{s}_{x:\overline{n}\vert}$
`\sx**{`⟨*lr*⟩`}`	`\sx**{x:\angln}`	$\ddot{s}_{x:\overline{n}\vert}$
`\aringx{`⟨*lr*⟩`}`	`\aringx{x:\angln}`	$\mathring{a}_{x:\overline{n}\vert}$

† Calligraphic letters obtained using `\mathcal`. These specific versions of $\mathscr{L}$ and $\mathscr{D}$ require package rsfso (Sharpe, 2015). Standard versions are $\mathcal{L}$ and $\mathcal{D}$.

Command `\@actinssc` automatically provides the two shortcuts for insurance benefits, command `\@actannsc` provides the three shortcuts for annuity benefits and command `\@actothersc` provides a single shortcut for ⟨*symbol*⟩.

For example, the package defines the shortcut `\px` with the equivalent of

```
\newcommand{\px}{\@actothersc{p}}
```

shortcuts `\Ax` and `\Ax*` with

```
\newcommand{\Ax}{\@actinssc{A}}
```

and shortcuts \ax, \ax* and \ax** with

```
\newcommand{\ax}{\@actannsc{a}}
```

Remark. When used in the preamble of a document, the above commands need to be protected by a \makeatletter ... \makeatother pair since they make use of the reserved character @. Therefore, to define shortcuts, say, \Bx and \Bx* to the imaginary benefits B and $\bar{B}$, one would write in the preamble

```
\makatletter
\newcommand{\Bx}{\@actinssc{B}}
\makeatother
```

4.2 Symbols for premiums, reserves and paid-up insurance

Symbols for premiums, reserves and paid-up insurance come in two main variants: without an explicit benefit between parentheses for insurances payable at the end of the year of death, and with the type of benefit specified for all other insurances and annuities.

Table 2 lists two sets of shortcuts to compose symbols for premiums, reserves and paid-up insurance. Shortcuts from the first set take in mandatory argument the content of the ⟨*lr*⟩ subscript of actuarial symbols. Those from the second set require a complete benefit symbol in argument. One may use the shortcuts of Table 1 to this effect. Again, only the mandatory arguments are given in the table, but all commands accept the optional arguments ⟨*ll*⟩, ⟨*ul*⟩ and ⟨*ur*⟩ of \actsymb.

\@actpremres The package eases definition of additional shortcut macros similar to the second set of Table 2 using the internal command

\@actpremres{⟨*principle*⟩}

It defines shortcuts for discrete (default) or continuous (* variant) premiums, reserves and paid-up insurance. For example, the package defines shortcuts \premium and \premium* with

```
\newcommand{\premium}{\@actpremres{P}}
```

The remark at the end of section 4.1 also applies here.

4.3 Auxiliary symbols

Table 3 lists shortcuts for a few common auxiliary symbols used in the lower right subscript $\boxed{\text{III}}$.

Table 2: Shortcuts for premiums, reserves and paid-up insurance. All commands accept the optional arguments ⟨*ll*⟩, ⟨*ul*⟩ and ⟨*ur*⟩ of `\actsymb`.

Definition	Example	Output
`\Px{`⟨*lr*⟩`}`	`\Px[h]{x}`	${}_hP_x$
`\Vx{`⟨*lr*⟩`}`	`\Vx[k]{x}`	${}_kV_x$
`\Wx{`⟨*lr*⟩`}`	`\Wx[k]{x}`	${}_kW_x$
`\premium{`⟨*benefit*⟩`}`	`\premium[t]{\Ax*{x}}`	${}_tP(\bar{A}_x)$
`\premium*{`⟨*benefit*⟩`}`	`\premium*[t]{\Ax*{x:\angln}}`	${}_t\bar{P}(\bar{A}_{x:\overline{n}\rceil})$
`\reserve{`⟨*benefit*⟩`}`	`\reserve[t]{\ax**{x}}`	${}_tV(\ddot{a}_x)$
`\reserve*{`⟨*benefit*⟩`}`	`\reserve*[t]{\ax*{x}}`	${}_t\bar{V}(\bar{a}_x)$
`\paidup{`⟨*benefit*⟩`}`	`\paidup[k]{\Ax*{x}}`	${}_kW(\bar{A}_x)$
`\paidup*{`⟨*benefit*⟩`}`	`\paidup*[k][h]{\Ax*{x}}`	${}^h_k\bar{W}(\bar{A}_x)$

4.4 Symbols for varying benefit insurance and annuities

Table 4 lists shortcuts for common two-letter symbols of varying benefit insurance and annuities. These shortcuts can be used as principal symbol in `\actsymb` or in the commands of Table 1.

`\@twoletinssc` `\@twoletannsc`

One may define additional shortcuts for two-letter insurance and annuity benefit symbols using the internal commands

`\@twoletinssc[`⟨*length*⟩`]{`⟨*symbol_1*⟩`}{`⟨*symbol_2*⟩`}`
`\@twoletannsc[`⟨*length*⟩`]{`⟨*symbol_1*⟩`}{`⟨*symbol_2*⟩`}`

These commands are similar to those of section 4.1: `\@twoletinssc` provides two shortcuts (standard and `*` variant), whereas `\@twoletannsc` provides three (standard, `*` and `**` variants).

4.5 First, second and third precedence

Table 5 lists shortcuts and aliases for the first, second and third precedence numbers, top and bottom. These shortcuts can be used in auxiliary symbols in `\actsymb` or in the commands of Table 1.

Table 3: Shortcuts for auxiliary symbols

Definition	Example	Output
`\term{`⟨*age*⟩`}{`⟨*duration*⟩`}`	`\Ax{\term{x}{n}}`	$A^{1}_{x:\overline{n}\vert}$
`\termxn`	`\Ax{\termxn}`	$A^{1}_{x:\overline{n}\vert}$
`\pureendow{`⟨*age*⟩`}{`⟨*duration*⟩`}`	`\Ax{\pureendow{x}{n}}`	$A_{x:\overline{n}\vert}^{1}$
`\pureendowxn`	`\Ax{\pureendowxn}`	$A_{x:\overline{n}\vert}^{1}$
`\endow{`⟨*age*⟩`}{`⟨*duration*⟩`}`	`\ax**{\endow{x}{n}}`	$\ddot{a}_{x:\overline{n}\vert}$
`\endowxn`	`\ax**{\endowxn}`	$\ddot{a}_{x:\overline{n}\vert}$
`\joint{`⟨*ages*⟩`}`[†]	`\Ax*{\joint{xy}z}`	$\bar{A}_{\overline{xy}z}$

[†] alias for `\overline`

Table 4: Shortcuts for varying benefit insurance and annuities

Definition	Output	Definition	Output
`\IA`	(IA)	`\DA`	(DA)
`\IA*`	$(I\bar{A})$	`\DA*`	$(D\bar{A})$
`\IbA`	$(\bar{I}A)$	`\DbA`	$(\bar{D}A)$
`\IbA*`	$(\bar{I}\bar{A})$	`\DbA*`	$(\bar{D}\bar{A})$
`\ImA`	$(I^{(m)}A)$	`\DmA`	$(D^{(m)}A)$
`\ImA*`	$(I^{(m)}\bar{A})$	`\DmA*`	$(D^{(m)}\bar{A})$
`\Ia`	(Ia)	`\Da`	(Da)
`\Ia*`	$(I\bar{a})$	`\Da*`	$(D\bar{a})$
`\Ia**`	$(I\ddot{a})$	`\Da**`	$(D\ddot{a})$
`\Is`	(Is)	`\Ds`	(Ds)
`\Is*`	$(I\bar{s})$	`\Ds*`	$(D\bar{s})$
`\Is**`	$(I\ddot{s})$	`\Ds**`	$(D\ddot{s})$

Table 5: Shortcuts and aliases for precedence numbers

Definition	Alias	Output
`\firsttop{`⟨*status*⟩`}`	`\itop{`⟨*status*⟩`}`	$A^{1}_{x:\overline{n}\vert}$
`\secondtop{`⟨*status*⟩`}`	`\iitop{`⟨*status*⟩`}`	A^{2}_{xyz}
`\thirdtop{`⟨*status*⟩`}`	`\iiitop{`⟨*status*⟩`}`	A^{3}_{xyz}
`\firsttop*{`⟨*status*⟩`}`	`\itop*{`⟨*status*⟩`}`	$A^{1}_{x:\overline{n}\vert}$
`\secondtop*{`⟨*status*⟩`}`	`\iitop*{`⟨*status*⟩`}`	A^{2}_{xyz}
`\thirdtop*{`⟨*status*⟩`}`	`\iiitop*{`⟨*status*⟩`}`	A^{3}_{xyz}
`\firstbottom{`⟨*status*⟩`}`	`\ibottom{`⟨*status*⟩`}`	A_{xyz}
`\secondbottom{`⟨*status*⟩`}`	`\iibottom{`⟨*status*⟩`}`	A_{xyz}
`\thirdbottom{`⟨*status*⟩`}`	`\iiibottom{`⟨*status*⟩`}`	A_{xyz}
`\firstbottom*{`⟨*status*⟩`}`	`\ibottom*{`⟨*status*⟩`}`	A_{xyz}
`\secondbottom*{`⟨*status*⟩`}`	`\iibottom*{`⟨*status*⟩`}`	A_{xyz}
`\thirdbottom*{`⟨*status*⟩`}`	`\iiibottom*{`⟨*status*⟩`}`	A_{xyz}

5 Package options

The package offers two options to control the placement of precedence numbers:

`alignpreced` always align top and bottom precedence numbers; makes `\nthtop` and `\nthbottom` equivalent to `\nthtop*` and `\nthbottom*`, respectively;

`compactpreced` always put precedence numbers close to the corresponding status; makes `\nthtop*` and `\nthbottom*` equivalent to `\nthtop` and `\nthbottom`, respectively.

Option `alignpreced` can be useful to simplify entry of uniformly positioned precedence numbers. On the other hand, option `compactpreced` is merely included as a complement to `alignpreced`. We do not recommended — nor see a reason — to use it as it basically renders inoperative commands `\nthtop*` and `\nthbottom*`.

A Comprehensive life contingencies symbol list

This appendix was inspired by Trivedi (2004). The title is a nod to the immensely useful *Comprehensive LaTeX Symbol List* of Pakin (2015).

The table below contains all the life contingencies symbols listed in Appendix 3 of Bowers et al. (1997) along with the code to compose them with actuarialsymbol (and therefore actuarialangle) loaded. Often times there are various ways to obtain a symbol; we tried to always present the most compact and legible option. Not all symbols require features of actuarialsymbol.

Calligraphic letters are typeset using `\mathcal`. The specific versions of $\mathscr{L}$ and $\mathscr{D}$ that appear in this table require package rsfso (Sharpe, 2015), which is *not* loaded by actuarialsymbol. Standard versions of the calligraphic letters are $\mathcal{L}$ and $\mathcal{D}$. See Table 299 of Pakin (2015) for other options.

Symbol	Code to compose the symbol
a	`a`
$a(x)$	`a(x)`
a_x	`a_x`
$a_{\overline{K}\vert}$	`\ax{\angl{K}}`
$\bar{a}_{\overline{n}\vert}$	`\ax*{\angln}`
$\bar{a}_{P_t}$	`\ax*{P_t}`
$\bar{a}_{\overline{T}\vert}$	`\ax*{\angl{T}}`
$\bar{a}_x$	`\ax*{x}`
$\bar{a}^h_r$	`\ax*{r}[h]`
$\bar{a}^i_{x+t}$	`\ax*{x + t}[i]`
$\bar{a}^r_{x+t}$	`\ax*{x + t}[r]`
$\ddot{a}_{\overline{K+1}\vert}$	`\ax**{\angl{K + 1}}`
$\ddot{a}^{(m)}_x$	`\ax**{x}[(m)]`
$\mathring{a}^{(m)}_x$	`\aringx{x}[(m)]`
$\ddot{a}^{\{m\}}_x$	`\ax**{x}[\{m\}]`
${}_j\ddot{a}_x$	`\ax**[j]{x}`
${}_*\ddot{a}_x$	`\ax**[*]{x}`
$a_{x:\overline{n}\vert}$	`\ax{\endowxn}`
$\bar{a}_{x:\overline{n}\vert}$	`\ax*{\endowxn}`

Symbol	Code to compose the symbol
$\ddot{a}_{x:\overline{n}\vert}$	`\ax**{\endowxn}`
$\ddot{a}^{(m)}_{x:\overline{n}\vert}$	`\ax**{\endowxn}[(m)]`
$\mathring{a}^{(m)}_{x:\overline{n}\vert}$	`\aringx{\endowxn}[(m)]`
$\ddot{a}^{\{m\}}_{x:\overline{n}\vert}$	`\ax**{\endowxn}[\{m\}]`
$\bar{a}_{\overline{x:\overline{n}\vert}}$	`\ax*{\joint\endowxn}`
${}^{2}\bar{a}_{x:\overline{n}\vert}$	`\ax*[][2]{\endowxn}`
${}_{n\vert}a_x$	`\ax[n|]{x}`
${}_{n\vert}\bar{a}_x$	`\ax*[n|]{x}`
${}_{n\vert}\ddot{a}_x$	`\ax**[n|]{x}`
${}_{n\vert}\ddot{a}^{(m)}_x$	`\ax**[n|]{x}[(m)]`
$\bar{a}^{1}_{xy\vert z}$	`\ax*{xy|z}[1]`
$\ddot{a}^{(m)}_{xy}$	`\ax**{xy}[(m)]`
$\ddot{a}_{xy:\overline{n}\vert}$	`\ax**{xy:\angln}`
${}^{2}\ddot{a}_{xy:\overline{n}\vert}$	`\ax**[][2]{xy:\angln}`
$\bar{a}_{x\vert y}$	`\ax*{x|y}`
$\bar{a}_{\overline{x_1 x_2 x_3}}$	`\ax*{\joint{x_1 x_2 x_3}}`
$(aA)(x)$	`\twoletsymb[0.6pt]{a}{A}(x)`
$(aA)_t$	`\twoletsymb[0.6pt]{a}{A}_t`
$(aC)_t$	`\twoletsymb[0.3pt]{a}{C}_t`
$(aF)_t$	`\twoletsymb[0.6pt]{a}{F}_t`
$(aU)_t$	`\twoletsymb[0.6pt]{a}{U}_t`
$(aV)(x)$	`\twoletsymb[0.6pt]{a}{V}(x)`
$(aV)_t$	`\twoletsymb[0.6pt]{a}{V}_t`
$A(h)$	`A(h)`
A_t	`A_t`
A_x	`\Ax{x}`
$\bar{A}_x$	`\Ax*{x}`
$A^{(m)}_x$	`\Ax{x}[(m)]`
$\bar{A}^{\mathrm{PR}}_x$	`\Ax*{x}[\text{PR}]`
$A^{1}_{x:\overline{n}\vert}$	`\Ax{\termxn}`
$A_{x:\overline{n}\vert}$	`\Ax{\endowxn}`

Symbol	Code to compose the symbol
$\bar{A}_{x:\overline{n}\vert}$	`\Ax*{\endowxn}`
$A_{x:\overline{n}\vert}^{1}$	`\Ax{\pureendowxn}`
${}_{j}A_{x}$	`\Ax[j]{x}`
${}_{*}A_{x}$	`\Ax[*]{x}`
$\bar{A}^{1}_{x:\overline{n}\vert}$	`\Ax*{\termxn}`
$\tilde{A}^{1}_{x:\overline{n}\vert}$	`\actsymb{\tilde{A}}{\termxn}`
${}^{2}A_{x:\overline{n}\vert}^{1}$	`\Ax[][2]{\pureendowxn}`
${}^{2}A^{1}_{x:\overline{n}\vert}$	`\Ax[][2]{\termxn}`
${}_{m\vert}\bar{A}_{x}$	`\Ax*[m|]{x}`
${}_{m\vert n}\bar{A}_{x}$	`\Ax*[m|n]{x}`
A_{xy}	`\Ax{xy}`
$A_{\overline{xy}}$	`\Ax{\joint{xy}}`
$A_{xy}^{(m)}$	`\Ax{xy}[(m)]`
$\bar{A}^{2}_{xy}$	`\Ax*{x\iitop{y}}`
$\bar{A}^{1}_{xy}$	`\Ax*{\itop{x}y}`
$A_{xy:\overline{n}\vert}$	`\Ax{xy:\angln}`
$\bar{A}^{1}_{\overline{xy}:\overline{n}\vert}$	`\Ax*{\itop{\joint{xy}}:\angln}`
${}^{2}A_{xy:\overline{n}\vert}$	`\Ax[][2]{xy:\angln}`
$\bar{A}_{wx}{}^{2}_{y}$	`\Ax*{wx\iitop{y}}`
$\bar{A}_{\overline{x_1 x_2 x_3}}$	`\Ax*{\joint{x_1 x_2 x_3}}`
${}_{k}AS$	`\actsymb[k]{\mathit{AS}}{}`
${}_{k}\widehat{AS}$	`\actsymb[k]{\widehat{\mathit{AS}}}{}`
$(AS)_{x+h}$	`\twoletsymb[0pt]{A}{S}_{x + h}`
(AAI)	`(\mathit{AAI})`
β	`\beta`
$\bar{\beta}$	`\bar{\beta}`
$\Gamma(\alpha)$	`\Gamma(\alpha)`
$b(u)$	`b(u)`
b_j	`b_j`
b_t	`b_t`
$b_f(t)$	`b_f(t)`

Symbol	Code to compose the symbol
B_t	`B_t`
$\hat{B}_{x+k}$	`\hat{B}_{x + k}`
$\hat{B}^{(3)}_{x+t}$	`\hat{B}_{x + t}^{(3)}`
$\hat{B}^{(j)}_{x+t}$	`\hat{B}_{x + t}^{(j)}`
${}_hBP$	`\actsymb[h]{\mathit{BP}}{}`
c	`c`
c_k	`c_k`
$\hat{c}_k$	`\hat{c}_k`
$c(t)$	`c(t)`
C_1	`C_1`
C_2	`C_2`
C_3	`C_3`
C_h	`C_h`
${}_kCV$	`\actsymb[k]{\mathit{CV}}{}`
$d^{(j)}_x$	`\dx{x}[(j)]`
${}_nd_x$	`\dx[n]{x}`
${}_nd^{(j)}_x$	`\dx[n]{x}[(j)]`
${}_nd^{(\tau)}_x$	`\dx[n]{x}[(\tau)]`
${}_tD_j$	`\actsymb[t]{D}{j}`
${}_{k+1}D$	`\actsymb[k + 1]{D}{}`
$(DA)^1_{x:\overline{n}\rceil}$	`\DA_{\termxn}`
$(D\bar{A})^1_{x:\overline{n}\rceil}$	`\DA*_{\termxn}`
${}_n\mathscr{D}_x$	`\Dx[n]{x}`
${}_n\mathscr{D}^{(j)}_x$	`\Dx[n]{x}[(j)]`
${}_n\mathscr{D}^{(\tau)}_x$	`\Dx[n]{x}[(\tau)]`
e	`e`
e_{h-1}	`e_{h - 1}`
e_x	`e_x`
$\mathring{e}_x$	`\eringx{x}`
$\hat{e}_k$	`\hat{e}_k`

Symbol	Code to compose the symbol
$\mathring{e}_{x:\overline{n}\rceil}$	`\eringx{\endowxn}`
e_{xy}	`e_{xy}`
$e_{\overline{xy}}$	`e_{\joint{xy}}`
E	`\mathrm{E}`
E	`E`
E_0	`E_0`
${}_nE_x$	`\Ex[n]{x}`
$(ES)_{x+h+t}$	`\twoletsymb[0.6pt]{E}{S}_{x + h + t}`
$ELRA$	`\mathit{ELRA}`
f	`f`
$f(u,t)$	`f(u, t)`
$f_S(s)$	`f_S(s)`
$F_X(x)$	`F_X(x)`
F_t	`F_t`
$F^{(k)}$	`F^{(k)}`
$F_S(s)$	`F_S(s)`
${}_kF$	`\actsymb[k]{F}{}`
G	`G`
$\hat{G}$	`\hat{G}`
$G(b)$	`G(b)`
$G(b)$	`G(b)`
$G(x;\alpha,\beta)$	`G(x; \alpha, \beta)`
$h(x)$	`h(x)`
$H(r)$	`H(r)`
$H(x;\alpha,\beta,x_0)$	`H(x; \alpha, \beta, x_0)`
${}_u(hp)^{(\tau)}_{x+t}$	`\actsymb[u]{\twoletsymb{h}{p}}{x + t}[(\tau)]`
$(h\mu)^{(j)}_{x+t}(u)$	`\actsymb{\twoletsymb{h}{\mu}}{x + t}[(j)](u)`
i'_{k+1}	`i'_{k + 1}`
$\hat{\imath}_{k+1}$	`\hat{\imath}_{k + 1}`
$i(s,s+t)$	`i(s, s + t)`

Symbol	Code to compose the symbol
I_k	`I_k`
I_d	`I_d`
$I_d(x)$	`I_d(x)`
${}_j i_k$	`\actsymb[j]{i}{k}`
$(IA)_x$	`\IA_x`
$(I\bar{A})_x$	`\IA*_x`
$(\bar{I}\bar{A})_x$	`\IbA*_x`
$(I^{(m)}\bar{A})_x$	`\ImA*_x`
$(IA)^1_{x:\overline{n}\rfloor}$	`\IA_{\termxn}`
J	`J`
$j(s, s+t, s+u)$	`j(s, s + t, s + u)`
${}_t\bar{k}_x$	`\actsymb[t]{\bar{k}}{x}`
K	`K`
$K(x)$	`K(x)`
$K(xy)$	`K(xy)`
$K(\overline{xy})$	`K(\joint{xy})`
ℓ_x	`\lx{x}`
$\ell_{[x]+k}$	`\lx{[x] + k}`
$\ell_x^{(\tau)}$	`\lx{x}[(\tau)]`
$l(x,u)$	`l(x, u)`
$l_f(x,u)$	`l_f(x, u)`
L	`L`
L_1	`L_1`
L_x	`L_x`
$L(h)$	`L(h)`
${}_tL$	`\actsymb[t]{L}{}`
${}_tL^{\underline{2}}$	`\actsymb[t]{L}{}[\underline{2}]`
${}_tL_e$	`\actsymb[t]{L}{e}`
${}_tL_e^{\underline{2}}$	`\actsymb[t]{L}{e}[\underline{2}]`
$\mathscr{L}(x)$	`\mathcal{L}(x)`

Symbol	Code to compose the symbol
$\mathscr{L}_x^{(\tau)}$	`\Lx{x}[(\tau)]`
$m(x)$	`m(x)`
m_x	`m_x`
$m_x^{(j)}$	`m_x^{(j)}`
$m_x^{(\tau)}$	`m_x^{(\tau)}`
$m_x^{\prime(j)}$	`m_x^{\prime (j)}`
$\mathrm{M}_X(t)$	`\mathrm{M}_X(t)`
$M(x)$	`M(x)`
$n(u)$	`n(u)`
N	`N`
$N(t)$	`N(t)`
$p(j)$	`p(j)`
$p(x)$	`p(x)`
p_k	`p_k`
$p_{[x]+r}$	`\px{[x] + r}`
$p^{*n}(x)$	`p^{*n}(x)`
${}_tp_x$	`\px[t]{x}`
${}_tp_x^{(\tau)}$	`\px[t]{x}[(\tau)]`
${}_tp_x^{\prime(j)}$	`\px[t]{x}[\prime (j)]`
${}_tp_{xy}$	`\px[t]{xy}`
${}_tp_{\overline{xy}}$	`\px[t]{\joint{xy}}`
${}_up_{\overline{xy}+t}$	`\px[u]{\joint{xy} + t}`
${}_tp_{\overline{x_1x_2\overset{k}{x_3}}}$	`\px[t]{\joint{x_1 x_2}\nthtop{k}{\joint{x_3}}}`
$P(x)$	`P(x)`
$P(s,t)$	`P(s, t)`
P_t	`P_t`
${}^TP_t$	`\actsymb[][T]{P}{t}`
P^a	`P^a`
P_x	`P_x`
${}_jP_x$	`\Px[j]{x}`

Symbol	Code to compose the symbol
$_{*}P_{x}$	`\Px[*]{x}`
$P^{A}_{x:\overline{n}\vert}$	`\Px{\endowxn}[A]`
$P_{x:\overline{n}\vert}$	`\Px{\endowxn}`
$P_{\overline{xy}}$	`\Px{\joint{xy}}`
$P^{1}_{x:\overline{n}\vert}$	`\Px{\:\termxn}`
$P_{x:\overline{n}\vert}^{1}$	`\Px{\pureendowxn}`
$P^{*n}(x)$	`P^{*n}(x)`
$_{h}P_{x}$	`\Px[h]{x}`
$_{h}P_{x:\overline{n}\vert}$	`\Px[h]{\endowxn}`
$(Pa)(x)$	`\twoletsymb[0.6pt]{P}{a}(x)`
$(Pa)_{t}$	`\twoletsymb[0.6pt]{P}{a}_t`
$P(\bar{A}_{x:\overline{n}\vert})$	`\premium{\Ax*{\endowxn}}`
$P(_{n\vert}\ddot{a}_{x})$	`\premium{\ax**[n|]{x}}`
$P(_{n\vert}\bar{a}_{x})$	`\premium{\ax*[n|]{x}}`
$P^{(m)}(\bar{A}_{x})$	`\premium{\Ax*{x}}[(m)]`
$P^{\{m\}}(\bar{A}_{x})$	`\premium{\Ax*{x}}[\{m\}]`
$P(\bar{A}^{\mathrm{PR}}_{x})$	`\premium{\Ax*{x}[\text{PR}]}`
$\bar{P}(\bar{A}_{x:\overline{n}\vert})$	`\premium*{\Ax*{\endowxn}}`
$\bar{P}(\bar{A}^{1}_{x:\overline{n}\vert})$	`\premium*{\Ax*{\termxn}}`
$\bar{P}(\bar{A}_{x:\overline{n}\vert}^{1})$	`\premium*{\Ax*{\pureendowxn}}`
$P^{(m)}(\bar{A}_{x:\overline{n}\vert})$	`\premium{\Ax*{\endowxn}}[(m)]`
$P^{(m)}(\bar{A}^{1}_{x:\overline{n}\vert})$	`\premium{\Ax*{\termxn}}[(m)]`
$_{h}\bar{P}(\bar{A}_{x})$	`\premium*[h]{\Ax*{x}}`
$_{h}\bar{P}(\bar{A}_{x:\overline{n}\vert})$	`\premium*[h]{\Ax*{\endowxn}}`
$_{h}P^{(m)}(\bar{A}_{x})$	`\premium[h]{\Ax*{x}}[(m)]`
$_{h}P^{(m)}(\bar{A}_{x:\overline{n}\vert})$	`\premium[h]{\Ax*{\endowxn}}[(m)]`
$_{h}P^{\{m\}}(\bar{A}_{x:\overline{n}\vert})$	`\premium[h]{\Ax*{\endowxn}}[\{m\}]`
$P(\bar{A}^{2}_{\overline{xyz}})$	`\premium{\Ax*{\joint{xy}\iitop{\joint{z}}}}`
$P(\bar{A}^{2}_{x\overline{yz}})$	`\premium{\Ax*{\ibottom{x}\iitop{y}z}}`
$\tilde{P}^{1}_{x:\overline{n}\vert}$	`\tilde{P}_{\:\termxn}`

Symbol	Code to compose the symbol
$q_{[x]+r}$	`\qx{[x] + r}`
$q_x^{(d)}$	`\qx{x}[(d)]`
$q_x^{(i)}$	`\qx{x}[(i)]`
$q_x^{(r)}$	`\qx{x}[(r)]`
$q_x^{(w)}$	`\qx{x}[(w)]`
$\hat{q}_{x+k}^{(j)}$	`\actsymb{\hat{q}}{x + k}[(j)]`
q_{xy}	`\qx{xy}`
${}_{k\|}q_x$	`\qx[k|]{x}`
${}_tq_x$	`\qx[t]{x}`
${}_tq_x^{(j)}$	`\qx[t]{x}[(j)]`
${}_tq_x^{(\tau)}$	`\qx[t]{x}[(\tau)]`
${}_tq_x^{\prime(j)}$	`\qx[t]{x}[\prime (j)]`
${}_{t\|u}q_x$	`\qx[t|u]{x}`
${}_nq_{xy}^{1}$	`\qx[n]{\itop{x}y}`
${}_nq_{xy}^{2}$	`\qx[n]{x\iitop{y}}`
${}_{k\|}q_{xy}$	`\qx[k|]{xy}`
${}_nq_{\substack{1\\xyz}}^{\substack{2}}$	`\qx[n]{\ibottom{x}\iitop{y}z}`
${}_\infty q_{\substack{12\\xyz}}^{\substack{3}}$	`\qx[\infty]{\ibottom*{x}\iibottom*{y}\iiitop{z}}`
r	`r`
r_C	`r_C`
r_F	`r_F`
r_N	`r_N`
$(rA)_t$	`\twoletsymb[0.6pt]{r}{A}_t`
$(rF)_t$	`\twoletsymb[0.6pt]{r}{F}_t`
$(rV)_t$	`\twoletsymb[0.6pt]{r}{V}_t`
R	`R`
$\tilde{R}$	`\tilde{R}`
$R(x,h,y)$	`R(x, h, y)`
$s(x)$	`s(x)`

Symbol	Code to compose the symbol
$\ddot{s}_{\overline{n}\|}$	`\sx**{\angln}`
$s(x,u)$	`s(x,u)`
$\bar{s}_{x:\overline{n}\|}$	`\sx*{\endowxn}`
$\ddot{s}_{x:\overline{n}\|}$	`\sx**{\endowxn}`
S	`S`
$S(t)$	`S(t)`
S_y	`S_y`
${}_kSC$	`\actsymb[k]{\mathit{SC}}{}`
T	`T`
$\tilde{T}$	`\tilde{T}`
T_x	`T_x`
T_{xy}	`T_{xy}`
$T_{\overline{xy}}$	`T_{\joint{xy}}`
$U(t)$	`U(t)`
U_t	`U_t`
$\hat{U}t$	`\hat{U}{t}`
v_t	`v_t`
$\tilde{v}_n$	`\tilde{v}_n`
V_i	`V_i`
V_t	`V_t`
${}_kV_x$	`\Vx[k]{x}`
${}_kV_{x:\overline{n}\|}$	`\Vx[k]{\endowxn}`
${}_kV^1_{x:\overline{n}\|}$	`\Vx[k]{\:\termxn}`
${}_kV_{x:\overline{\underline{1}}\|}$	`\Vx[k]{\pureendowxn}`
${}_kV_x^{\mathrm{FPT}}$	`\Vx[k]{x}[\text{FPT}]`
${}_tV^{\underline{1}}_{\overline{xy}:\overline{n}\|}$	`\Vx[t]{\itop{\group{xy}}:\angln}`
${}^h_kV_x$	`\Vx[k][h]{x}`
${}^h_kV_{x:\overline{n}\|}$	`\Vx[k][h]{\endowxn}`
${}^h_kV^{(m)}_{x:\overline{n}\|}$	`\Vx[k][h]{\endowxn}[(m)]`
${}^h_kV^{\mathrm{Mod}}_{x:\overline{n}\|}$	`\Vx[k][h]{\endowxn}[\text{Mod}]`

Symbol	Code to compose the symbol
${}_kV(_{n\|}\ddot{a}_x)$	`\reserve[k]{\ax**[n|]{x}}`
${}_t\bar{V}(_{n\|}\bar{a}_x)$	`\reserve*[t]{\ax*[n|]{x}}`
${}_t\bar{V}(\bar{A}_x)$	`\reserve*[t]{\Ax*{x}}`
${}_t\bar{V}(\bar{A}_{x:\overline{n\|}})$	`\reserve*[t]{\Ax*{\endowxn}}`
${}_t\bar{V}(\bar{A}^1_{x:\overline{n\|}})$	`\reserve*[t]{\Ax*{\termxn}}`
${}_t\bar{V}(\bar{A}_{x:\overline{n\|}^1})$	`\reserve*[t]{\Ax*{\pureendowxn}}`
${}_t\bar{V}(\bar{A}_x)^{\text{Mod}}$	`\reserve*[t]{\Ax*{x}}^{\text{Mod}}`
${}_tV(\bar{A}_{\overline{xy}})$	`\reserve[t]{\Ax*{\joint{xy}}}`
${}_tV^{\{1\}}(\bar{A}_x)$	`\reserve[t]{\Ax*{x}}[\{1\}]`
${}_kV(\bar{A}^{\text{PR}}_x)$	`\reserve[k]{\Ax*{x}[\text{PR}]}`
${}^h_kV(A^1_{x:\overline{n\|}})$	`\reserve[k][h]{\Ax{\termxn}}`
${}^h_t\bar{V}(\bar{A}_x)$	`\reserve*[t][h]{\Ax*{x}}`
${}^h_t\bar{V}(\bar{A}_{x:\overline{n\|}})$	`\reserve*[t][h]{\Ax*{\endowxn}}`
${}^h_t\bar{V}^{(m)}(\bar{A}_{x:\overline{n\|}})$	`\reserve*[t][h]{\Ax*{\endowxn}}[(m)]`
$w(x)$	`w(x)`
W_i	`W_i`
W_t	`W_t`
${}_kW$	`\Wx[k]{}`
${}_kW_x$	`\Wx[k]{x}`
${}_kW_{x:\overline{n\|}}$	`\Wx[k]{\endowxn}`
${}^h_kW_x$	`\Wx[k][h]{x}`
$(Wa)_t$	`\twoletsymb{W}{a}_t`
${}_k\bar{W}(A_x)$	`\paidup*[k]{\Ax{x}}`
${}_k\bar{W}(A_{x:\overline{n\|}})$	`\paidup*[k]{\Ax{\endowxn}}`
${}^h_k\bar{W}(A_x)$	`\paidup*[k][h]{\Ax{x}}`
(x)	`(x)`
$(x_1x_2\cdots x_m)$	`(x_1 x_2 \dotsm x_m)`
$(\overline{x_1x_2\cdots x_m})$	`(\joint{x_1 x_2 \dotsm x_m})`
$\overset{k}{\overline{x_1x_2\cdots x_m}}$	`\joint{x_1x_2 \dotsm}\nthtop{k}{\joint{x_m}}`

Symbol	Code to compose the symbol
$\overset{[k]}{\overline{x_1 x_2 \cdots x_m}}$	`\joint{x_1x_2 \dotsm}\nthtop{[k]}{\joint{x_m}}`
X_i	`X_i`
$X(\theta)$	`X(\theta)`
Y	`Y`
$y(s, s+m)$	`y(s, s + m)`
$Y(t, n)$	`Y(t, n)`
z_t	`z_t`
Z	`Z`
${}_m Z_t$	`\actsymb[m]{Z}{t}`
α	`\alpha`
$\alpha(m)$	`\alpha(m)`
$\bar{\alpha}$	`\bar{\alpha}`
α^{CRVM}	`\alpha^{\text{CRVM}}`
β	`\beta`
$\beta(m)$	`\beta(m)`
$\bar{\beta}$	`\bar{\beta}`
β^{CRVM}	`\beta^{\text{CRVM}}`
$\beta(x, u)$	`\beta(x, u)`
$\Gamma(\alpha)$	`\Gamma(\alpha)`
δ	`\delta`
δ_t	`\delta_t`
θ	`\theta`
$\lambda(t)$	`\lambda(t)`
$\lambda(t, n)$	`\lambda(t, n)`
Λ	`\Lambda`
Λ_h	`\Lambda_h`
$\mu(x)$	`\mu(x)`
$\mu_x(t)$	`\mu_x(t)`

Symbol	Code to compose the symbol
$\mu_x^{(d)}$	`\mu_x^{(d)}`
$\mu_x^{(i)}$	`\mu_x^{(i)}`
$\mu_x^{(w)}$	`\mu_x^{(w)}`
$\mu_x^{(j)}(t)$	`\mu_x^{(j)}(t)`
$\mu_x^{(\tau)}(t)$	`\mu_x^{(\tau)}(t)`
$\mu_{xy}(t)$	`\mu_{xy}(t)`
$\mu_{\overline{xy}}(t)$	`\mu_{\joint{xy}}(t)`
$\mu(x,u)$	`\mu(x, u)`
π_h	`\pi_h`
π_t	`\pi_t`
ρ	`\rho`
τ	`\tau`
$\phi(x)$	`\phi(x)`
$\phi(x,u)$	`\phi(x, u)`
$\Psi(u)$	`\Psi(u)`
$\tilde{\Psi}(u)$	`\tilde{\Psi}(u)`
$\Psi(u,t)$	`\Psi(u, t)`
$\Psi(u;w)$	`\Psi(u; w)`
$\tilde{\Psi}(u;w)$	`\tilde{\Psi}(u; w)`
ω	`\omega`

B Implementation

This appendix contains the annotated source code of the package. Most readers can stop reading here.

B.1 Required packages

RequirePackage

The package depends on packages amsmath (American Mathematical Society, 2002) and actuarialangle (Goulet, 2017).

```
\RequirePackage{amsmath}
\RequirePackage{actuarialangle}
```

B.2 Package options

\ifacts@alignpreced
\ifacts@acompactpreced

We define two flags to keep track of the type of alignment for precedence numbers. Both are false by default.

```
\newif\ifacts@alignpreced   \acts@alignprecedfalse
\newif\ifacts@compactpreced \acts@compactprecedfalse
```

\DeclareOption

Declaration of the package options and processing.

```
\DeclareOption{alignpreced}{\acts@alignprecedtrue}
\DeclareOption{compactpreced}{\acts@compactprecedtrue}
\ProcessOptions
```

B.3 Actuarial symbol

We face three main challenges when trying to compose actuarial symbols: position a subscript and a superscipt to the left of a main symbol; ensure that the left and right subscripts and superscripts are vertically aligned; maintain consistency with the placement of subscripts and superscripts elsewhere in the document.

B.3.1 User level and parsing commands

actsymb

We first define the user level command.

```
\DeclareRobustCommand{\actsymb}{\acts@actsymb}
```

\acts@actsymb
\acts@@actsymb
\acts@@@actsymb
\acts@@@@actsymb

With its unusual syntax, \actsymb requires four parsing macros to pass the arguments to the actual workhorse \@actsymbol.

```
\newcommand\acts@actsymb{%
  \@ifnextchar[{\acts@@actsymb}%
```

```
                {\acts@@actsymb[]}}
\newcommand\acts@@actsymb{}
\def\acts@@actsymb[#1]{%
  \@ifnextchar[{\acts@@@actsymb[#1]}%
                {\acts@@@actsymb[#1][]}}
\newcommand\acts@@@actsymb{}
\def\acts@@@actsymb[#1][#2]{%
  \@ifnextchar[{\acts@@@@actsymb[#1][#2]}%
                {\acts@@@@actsymb[#1][#2][]}}
\newcommand\acts@@@@actsymb{}
\def\acts@@@@actsymb[#1][#2][#3]#4#5{%
  \@ifnextchar[{\@actsymbol[#1][#2][#3]{#4}{#5}}%
                {\@actsymbol[#1][#2][#3]{#4}{#5}[]}}
```

B.3.2 Symbol construction

`\@actsymbol` We now define the workhorse to compose an actuarial symbol allowing for auxiliary symbols on all four corners around a principal symbol. The macro `\@actsymbol` has the following six arguments, using the notation from of the schematics representations (1) and (2):

1. lower left subscript I; may be empty;
2. upper left superscript II; may be empty;
3. principle symbol P; when empty a standard symbol is typeset;
4. principal symbol S; assumed present;
5. lower right subscript III; assumed present;
6. upper right superscript IV; may be empty.

The definition below is heavily inspired by the code of `\prescript` from package mathtools (Høgholm and Madsen, 2015) which, as reported by the author, is itself based on a posting to `comp.text.tex` by Michael J. Downes. Some of the comments below are still his.

```
\def\@actsymbol[#1][#2][#3]#4#5[#6]{
```

We put the principle symbol and all subscripts and superscript into horizontal boxes using `\@mathmeasure` of package amsmath.

```
  \@mathmeasure\z@\displaystyle{#3}
  \@mathmeasure\@ne\scriptstyle{#1}
  \@mathmeasure\tw@\scriptstyle{#2}
  \@mathmeasure\thr@@\scriptstyle{#5}
  \@mathmeasure4\scriptstyle{#6}
```

Do not let a preceding mathord symbol approach without any intervening space.

```
  \mathord{}
```

Right align the left subscript and superscript (if there is a superscript) by adjusting the width of their horizontal boxes.

```
\ifdim \wd\tw@>\z@ \ifdim \wd\tw@>\wd\@ne
  \setbox\@ne\hbox to\wd\tw@{\hfil\unhbox\@ne}
\else
  \setbox\tw@\hbox to\wd\@ne{\hfil\unhbox\tw@}
\fi\fi
```

Bottom align the left and right subscripts by making their heights equal.

```
\ifdim \ht\@ne>\ht\thr@@
  \ht\thr@@=\ht\@ne
\else
  \ht\@ne=\ht\thr@@
\fi
```

Actual symbol construction. First the case where there is at least one superscript (the nested conditionals emulate an OR condition).

```
\ifnum\ifdim \wd\tw@>\z@ 1\else\ifdim \wd4>\z@ 1\else 0\fi\fi
  =1
```

To ensure equal spacing with the subscripts on both sides of the principal symbol, make the depths of the left and right supercripts equal.

```
  \ifdim \dp\tw@>\dp4 \dp4=\dp\tw@\else \dp\tw@=\dp4\fi
```

Typesetting of the left subscript and superscript. Use `\mathopen` to suppress space between those and the principal symbol even when the latter is not of type ord.

```
  \mathopen{\vphantom{#4}^{\box\tw@}\sb{\box\@ne}}%
```

Typesetting of the principal symbol and the right subscript and superscript. The principal symbol is either a principal symbol alone or a principle symbol and a benefit symbol between parentheses. In the latter case, we make sure to align the subscripts and superscripts only around de principle symbol.

```
  \ifdim\wd\z@=\z@
    #4^{\box4}\sb{\box\thr@@}%
  \else
    #3^{\box4}\sb{\vphantom{\copy\thr@@}}(#4\sb{\box\thr@@})%
  \fi
\else
```

Same ideas as above in the simpler case without superscripts. That way, TEX's default placement of subscripts and superscripts is maintained.

```
  \mathopen{\vphantom{#4}\sb{\box\@ne}}%
  \ifdim\wd\z@=\z@
    #4\sb{\box\thr@@}%
```

```
    \else
      #3(#4\sb{\box\thr@@})%
    \fi
  \fi
}
```

B.3.3 Shortcuts for basic symbols of life tables, insurance and annuities

\@actinssc
\@actannsc
\@actothersc

We first define the internal macros and parsing macros used to define shortcuts for insurance benefits (\@actinssc), annuity benefits (\@actannsc) and simple symbols (\@actothersc).

```
\newcommand\@actinssc[1]{%
  \@ifstar{\acts@actsc{\bar{#1}}}%
          {\acts@actsc{#1}}}
\newcommand\@actannsc[1]{%
  \@ifstar{\@ifstar{\acts@actsc{\ddot{#1}}}%
                   {\acts@actsc{\bar{#1}}}}
          {\acts@actsc{#1}}}
\newcommand\acts@actsc[1]{%
  \@ifnextchar[{\acts@@actsc{#1}}%
               {\acts@@actsc{#1}[]}}
\let\@actothersc\acts@actsc
\newcommand\acts@@actsc{}
\def\acts@@actsc#1[#2]{%
  \@ifnextchar[{\acts@@@actsc{#1}[#2]}%
               {\acts@@@actsc{#1}[#2][]}}
\newcommand\acts@@@actsc{}
\def\acts@@@actsc#1[#2][#3]#4{%
  \@ifnextchar[{\@actsymbol[#2][#3][]{#1}{#4}}%
               {\@actsymbol[#2][#3][]{#1}{#4}[]}}
```

\DeclareRobustCommand

We can now define all the shortcuts of Table 1.

```
\DeclareRobustCommand{\lx}{\@actothersc {\ell}}
\DeclareRobustCommand{\Lx}{\@actothersc {\mathcal{L}}}
\DeclareRobustCommand{\dx}{\@actothersc d}
\DeclareRobustCommand{\Dx}{\@actothersc{\mathcal{D}}}
\DeclareRobustCommand{\px}{\@actothersc p}
\DeclareRobustCommand{\qx}{\@actothersc q}
\DeclareRobustCommand{\Ax}{\@actinssc A}
\DeclareRobustCommand{\Ex}{\@actinssc E}
\DeclareRobustCommand{\ax}{\@actannsc a}
\DeclareRobustCommand{\sx}{\@actannsc s}
\DeclareRobustCommand{\aringx}{\@actothersc{\mathring{a}}}
```

```
\DeclareRobustCommand{\eringx}{\@actothersc{\mathring{e}}}
```

B.3.4 Shortcuts for premiums, reserves and paid-up insurance

\@actpremres Not unlike above, we first define the internal and parsing macros used to create shortcut for premiums, reserves and paid-up insurance symbols.

```
\newcommand\@actpremres[1]{%
  \@ifstar{\acts@actpremres{\bar{#1}}}%
          {\acts@actpremres{#1}}}
\newcommand\acts@actpremres[1]{%
  \@ifnextchar[{\acts@@actpremres{#1}}%
               {\acts@@actpremres{#1}[]}}
\newcommand\acts@@actpremres{}
\def\acts@@actpremres#1[#2]{%
  \@ifnextchar[{\acts@@@actpremres{#1}[#2]}%
               {\acts@@@actpremres{#1}[#2][]}}
\newcommand\acts@@@actpremres{}
\def\acts@@@actpremres#1[#2][#3]#4{%
  \@ifnextchar[{\@actsymbol[#2][#3][#1]{{#4}}{}}%
               {\@actsymbol[#2][#3][#1]{{#4}}{}[]}}
```

\DeclareRobustCommand Then we can define the shortcuts of Table 2.

```
\DeclareRobustCommand{\Px}{\@actothersc P}
\DeclareRobustCommand{\Vx}{\@actothersc V}
\DeclareRobustCommand{\Wx}{\@actothersc W}
\DeclareRobustCommand{\premium}{\@actpremres P}
\DeclareRobustCommand{\reserve}{\@actpremres V}
\DeclareRobustCommand{\paidup}{\@actpremres W}
```

B.3.5 Shortcuts for auxiliary symbols

\DeclareRobustCommand Here we define the shortcuts for common auxiliary symbols listed in Table 3. Command \joint is simply defined as an alias of \overline.

```
\DeclareRobustCommand{\term}[2]{\itop{#1}:\angl{#2}}
\DeclareRobustCommand{\termxn}{{\itop{x}:\angln}}
\DeclareRobustCommand{\pureendow}[2]{#1:\itop{\angl{#2}}}
\DeclareRobustCommand{\pureendowxn}{{x:\itop{\angln}}}
\DeclareRobustCommand{\endow}[2]{#1:\angl{#2}}
\DeclareRobustCommand{\endowxn}{{x:\angln}}
\let\joint\overline
```

B.4 Two-letter symbols

\twoletkern
\twoletsymb

The definition of the user level command \twoletsymb is pretty straighforward.

```
\newlength{\twoletkern}
\setlength{\twoletkern}{1.2pt}
\DeclareRobustCommand{\twoletsymb}[3][\twoletkern]{(#2\kern-#1#3)}
```

\@twoletinssc
\@twoletannsc

Following the same lines as above, we define two internal macros to create shortcuts for two-letter insurance and annuity benefit symbols.

```
\newcommand\@twoletinssc[3][\twoletkern]{%
  \@ifstar{\twoletsymb[#1]{#2}{\bar{#3}}}%
          {\twoletsymb[#1]{#2}{#3}}}
\newcommand\@twoletannsc[3][\twoletkern]{%
  \@ifstar{\@ifstar{\twoletsymb[#1]{#2}{\ddot{#3}}}%
                   {\twoletsymb[#1]{#2}{\bar{#3}}}}%
          {\twoletsymb[#1]{#2}{#3}}}
```

\newcommand

Follow the shortcuts of Table 4. Note that we used a smaller negative kerning adjustment for symbols annuity symbols.

```
\newcommand{\IA}{\@twoletinssc IA}
\newcommand{\IbA}{\@twoletinssc{\bar{I}}A}
\newcommand{\ImA}{\@twoletinssc{I^{(m)}}A}
\newcommand{\DA}{\@twoletinssc DA}
\newcommand{\DbA}{\@twoletinssc{\bar{D}}A}
\newcommand{\DmA}{\@twoletinssc{D^{(m)}}A}
\newcommand{\Ia}{\@twoletannsc[0.5\twoletkern]Ia}
\newcommand{\Is}{\@twoletannsc[0.5\twoletkern]Is}
\newcommand{\Da}{\@twoletannsc[0.5\twoletkern]Da}
\newcommand{\Ds}{\@twoletannsc[0.5\twoletkern]Ds}
```

B.5 Precedence numbers

The system of precedence numbers builds on a backbone that used to be part of package actuarialangle. The author of the code is unknown. Some of the comments on \@precendence, below, are his or hers.

B.5.1 User level lengths and commands

\nthtopsep
\nthtopskip
\nthbottomsep
\nthbottomskip

Let us start by defining the lengths needed to position the precedence numbers above or below the statuses.

```
\newlength{\nthtopsep}
\setlength{\nthtopsep}{2\p@}
```

```
\newlength{\nthtopskip}
\setlength{\nthtopskip}{7\p@}
\newlength{\nthbottomsep}
\setlength{\nthbottomsep}{2\p@}
\newlength{\nthbottomskip}
\setlength{\nthbottomskip}{9\p@}
```

\nthtop
\nthbottom

Next up are the two user level commands and the internal commands that call the workhorse \@precedence.

```
\DeclareRobustCommand{\nthtop}{\@ifstar\@varnthtop\@nthtop}
\DeclareRobustCommand{\nthbottom}{\@ifstar\@varnthbottom\@nthbottom}
\newcommand{\@nthtop}[3][\nthtopsep]{%
  \mathpalette{\@precedence t\z@{#1}{#2}}{#3}}
\newcommand{\@varnthtop}[3][\nthtopskip]{%
  \mathpalette{\@precedence t{#1}\z@{#2}}{#3}}
\newcommand{\@nthbottom}[3][\nthbottomsep]{%
  \mathpalette{\@precedence b\z@{#1}{#2}}{#3}}
\newcommand{\@varnthbottom}[3][\nthbottomskip]{%
  \mathpalette{\@precedence b{#1}\z@{#2}}{#3}}
```

\@nthtop
\@nthbottom

With the internal commands defined we can now process the package options. Option `alignpreced` makes the internal macros \@nthtop and \@nthbottom equivalent to \@varnthtop and \@varnthbottom, respectively.

```
\ifacts@alignpreced
  \let\@nthtop\@varnthtop
  \let\@nthbottom\@varnthbottom
\fi
```

\@varnthtop
\@varnthbottom

Option `compactpreced` does the opposite.

```
\ifacts@compactpreced
  \let\@varnthtop\nthtop
  \let\@varnthbottom\nthbottom
\fi
```

B.5.2 Number and status positioning

\@precedence

We now define the workhorse to position precedence numbers above or below statuses, smashed so that the height of the auxiliary symbol containing the call remains unaffected. The macro \@precedence has the following six arguments:

1. `t` for top or `b` for bottom;
2. baseline skip between the top and bottom symbols;
3. spacing between the top and bottom symbols;

4. first argument from the user;
5. one of math style selecting commands (`\displaystyle`, `\textstyle`, `\scriptstyle`, `\scriptscriptstyle`) from `\mathpalette`;
6. second argument given by the user.

This peculiar ordering of the arguments is done to work around the restriction of `\mathpalette` that it only reads two arguments.

```
\def\@precedence#1#2#3#4#5#6{%
  \setbox\tw@\hbox{$\m@th#5#4$}%
  \setbox\z@\hbox{$\m@th#5#6$}
  \dimen@\wd\z@
  \vbox to\ht\z@{%
    \baselineskip=#2
    \lineskip=#3
    \lineskiplimit\lineskip
    \if b#1\relax\box\z@\else\vss\fi
    \hbox to\dimen@{\hss\unhbox\tw@\hss}%
    \if t#1\relax\box\z@\else\vss\fi
  }
}
```

B.5.3 Shortcuts and aliases

`\DeclareRobustCommand` We finish off by defining the shortcuts and aliases of Table 5.

```
\DeclareRobustCommand{\firsttop}{%
  \@ifstar{\@varnthtop{1}}{\@nthtop{1}}}
\DeclareRobustCommand{\secondtop}{%
  \@ifstar{\@varnthtop{2}}{\@nthtop{2}}}
\DeclareRobustCommand{\thirdtop}{%
  \@ifstar{\@varnthtop{3}}{\@nthtop{3}}}
\DeclareRobustCommand{\firstbottom}{%
  \@ifstar{\@varnthbottom{1}}{\@nthbottom{1}}}
\DeclareRobustCommand{\secondbottom}{%
  \@ifstar{\@varnthbottom{2}}{\@nthbottom{2}}}
\DeclareRobustCommand{\thirdbottom}{%
  \@ifstar{\@varnthbottom{3}}{\@nthbottom{3}}}
\let\itop\firsttop
\let\iitop\secondtop
\let\iiitop\thirdtop
\let\ibottom\firstbottom
\let\iibottom\secondbottom
\let\iiibottom\thirdbottom
```

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