The mandi package

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1 Introduction

This package provides a collection of commands useful in introductory physics and astronomy. The underlying philosophy is that the user, potentially an introductory student, should just type the name of a physical quantity, with a numerical value if needed, without having to think about the units. `mandi` will typeset everything correctly. For symbolic quantities, the user should type only what is necessary to get the desired result. What one types should correspond as closely as possible to what one thinks when writing. The package name derives from *Matter & Interactions*[1] by Ruth Chabay and Bruce Sherwood. The package certainly is rather tightly tied to that textbook but can be used for typesetting any document that requires consistent physics notation. With `mandi` many complicated expressions can be typeset with just a single command. Great thought has been given to command names and I hope users find the conventions logical and easy to remember.

There are other underlying philosophies and goals embedded within `mandi`, all of which are summarized here. They are

- to employ a *type what you think* model for remembering commands
- to relieve the user of having to explicitly worry about typesetting SI units
- to enforce certain concepts that are too frequently merged, such as the distinction between a vector quantity and its magnitude (e.g. we often use the same name for both)
- to enforce consistent terminology in the naming of quantities, with names that are both meaningful to introductory students and accurate (e.g. *duration* vs. *time*)
- to enforce consistent notation, especially for vector quantities

I hope that using `mandi` will cause users to form good habits that benefit physics students.

2 Building From Source

I am assuming the user will use pdfLaTeX, which creates PDF files as output, to build the documentation. I have not tested the build with with standard LaTeX, which creates DVI files.

[1] See the *Matter & Interactions* home page at `http://www.matterandinteractions.org/` for more information about this innovative introductory calculus-based physics curriculum.

3 Loading the Package

To load `mandi` with its default options, simply put the line `\usepackage{mandi}` in your document's preamble. To use the package's available options, put the line `\usepackage[options]{mandi}` in your document's preamble. There are five available options, with one option being based on the absence of two of the others. The options are described below.

- **italicvectors** gives italic letters for the kernels of vector names. Otherwise, the letters are in Roman.
- **doubleabsbars** gives double bars in symbols for vector magnitudes. Otherwise, single bars are used. Double bars may be more familiar to students from their calculus courses.
- **baseunits** causes all units to be displayed in *baseunits* form, with SI base units. No solidi (slashes) are used. Positive and negative exponents are used to denote powers of various base units.
- **drvdunits** causes all units to be displayed, when possible, in *drvdunits* form, with SI derived units. Students may already be familiar with many of these derived units.
- If neither **baseunits** nor **drvdunits** is specified (the default), units are displayed in what I call *tradunits* form, which is typically the way they would traditionally appear in textbooks. Units in this form frequently hide the underlying physical meaning and are probably not best pedagogically but are familiar to students and teachers. In this document, the default is to use traditional units. As you will see later, there are ways to override these options either temporarily or permanently.

`mandi` coexists with the `siunitx` package. While there is some functional overlap between the two packages, `mandi` is completely independent of `siunitx`.

`mandi` coexists with the `physymb` package, with which there are also functional overlaps and a few conflicts with identically named commands. If you wish to use `physymb` and `mandi` in the same document, be certain to load `physymb` first. `mandi` will detect its presence and behave accordingly.

4 Usage

So what does `mandi` allow you to do? Suppose you want to typeset a calculation of a particle's kinetic energy (assume the magnitude of the particle's velocity is much less than the magnitude of light's velocity). You could use

```
\[ K \approx \frac{1}{2}\left(\unit{2}{\kg}\right)\left(\unit{2}{\m\per\s}\right)^2 \]
```

$$K \approx \frac{1}{2}\left(2\,\mathrm{kg}\right)\left(2\,\mathrm{m/s}\right)^2$$

but `mandi` lets you do something more logical and more readable, like this

```
\[ K \approx \onehalf (\mass{2})(\velocity{2})^2 \]
```

$$K \approx \frac{1}{2}\left(2\,\mathrm{kg}\right)\left(2\,\mathrm{m/s}\right)^2$$

which produces the same output. In the second example, note that the units are abstracted so the user need not remember them.

The second way is more readable if you come back to the source document, perhaps having not looked at it for a while. Suppose you want to use vectors quantities. That's no problem because `mandi` handles vector quantities.

```
Calculate the magnitude of \momentum{\mivector{3,2,5}}.
```

Calculate the magnitude of $\langle 3, 2, 5\rangle\ \mathrm{kg}\cdot\mathrm{m/s}$.

The underlying strategy is to *think about how you would say what you want to write and then write it the way you would say it.* With a few exceptions, this is how `mandi` works. You need not worry about units because `mandi` knows what SI units go with which physical quantities. You can define new quantities so that `mandi` knows about them and in doing so, you give the new quantities the same names they would normally have.

If you want to save time in writing out the energy principle, just use

```
\energyprinciple
```

$E_{\mathrm{sys,f}} = E_{\mathrm{sys,i}} + W_{\mathrm{ext}} + Q$

which, as you can see, takes fewer keystrokes and it's easier to remember.

This barely scratches the surface in describing `mandi` so continue reading this document to see everything this package can do.

5 Features and Commands

5.1 Autosized Parentheses

An experimental feature of `mandi` is autosized parentheses in math mode. This means you need never use `\left(` or `\right)`. Just use unadorned parentheses and they will size correctly. Note that this only works in math mode, only works for parentheses and not for other delimiters.

```
(\oofpezmathsymbol) is how it looks in text mode.
```

$(\frac{1}{4\pi\epsilon_{\mathrm{o}}})$ is how it looks in text mode.

```
\( (\oofpezmathsymbol) \) is how it looks in math mode.
```

$\left(\frac{1}{4\pi\epsilon_{\mathrm{o}}}\right)$ is how it looks in math mode.

5.2 SI Base Units

This is not a tutorial on SI units and the user is assumed to be familiar with SI rules and usage. Begin by defining shortcuts for the units for the seven SI base quantities: *spatial displacement* (what others call *length*), *mass*, *temporal displacement* (what others call *time*, but we will call it *duration* in most cases), *electric current*, *thermodynamic temperature*, *amount*, and *luminous intensity*. These shortcuts are used internally and need not explicitly be invoked by the user.

`\m`
: Command for metre, the SI unit of spatial displacement (length).

`\kg`
: Command for kilogram, the SI unit of mass.

`\s`
: Command for second, the SI unit of temporal displacement (duration).

`\A`
: Command for ampere, the SI unit of electric current.

`\K`
: Command for kelvin, the SI unit of thermodynamic temperature.

`\mol`
: Command for mole, the SI unit of amount.

`\cd`
: Command for candela, the SI unit of luminous intensity.

If `mandi` was invoked with **baseunits**, then every physical quantity will have a unit that is some product of powers of these seven base SI units. Exceptions are angular quantities, which will include either degrees or radians depending upon the application. Again, this is what we mean by *baseunits* form.

Certain combinations of the SI base units have nicknames and each such combination and nickname constitutes a *derived unit*. Derived units are no more physically meaningful than the base units, they are merely nicknames for particular combinations of base units. An example of a derived unit is the newton, for which the symbol (it is not an abbreviation) is N. However, the symbol N is merely a nickname for a particular combination of base units. It is not the case that every unique combination of base units has a nickname, but those that do are usually named in honor of a scientist. Incidentally, in such cases, the symbol is capitalized but the *name* of the unit is **never** capitalized. Thus we would write the name of the derived unit of force as newton and not Newton. Again, using these select nicknames for certain combinations of base units is what we mean by *drvdunits* form.

5.3 Defining Physics Quantities

`\newphysicsquantity{`⟨*newname*⟩`}{`⟨*baseunits*⟩`}[`⟨*drvdunits*⟩`][`⟨*tradunits*⟩`]`
: Defines a new physics quantity and its associated commands.

Using this command causes several things to happen.

- A command `\newname{`⟨*magnitude*⟩`}`, where newname is the first argument of `\newphysicsquantity`, is created that takes one mandatory argument, a numerical magnitude. Subsequent use of your defined scalar quantity can be invoked by typing `\newname{`⟨*magnitude*⟩`}` and the units will be typeset according to the options given when `mandi` was loaded. Note that if the *drvdunits* and *tradunits* forms are not specified, they will be populated with the *baseunits* form.
- A command `\newnamebaseunit{`⟨*magnitude*⟩`}` is created that expresses the quantity and its units in *baseunits* form.
- A command `\newnamedrvdunit{`⟨*magnitude*⟩`}` is created that expresses the quantity and its units in *drvdunits* form. This command is created whether or not the first optional argument is provided.
- A command `\newnametradunit{`⟨*magnitude*⟩`}` is created that expresses the quantity and its units in *tradunits* form. This command is created whether or not the first optional argument is provided.
- A command `\newnameonlybaseunit{`⟨*magnitude*⟩`}` is created that expresses **only** the quantity's units in *baseunits* form.
- A command `\newnameonlydrvdunit{`⟨*magnitude*⟩`}` is created that expresses **only** the quantity's units in *drvdunits* form.
- A command `\newnameonlytradunit{`⟨*magnitude*⟩`}` is created that expresses **only** the quantity's units in *tradunits* form.
- A command `\newnamevalue{`⟨*magnitude*⟩`}` is created that expresses **only** the quantity's numerical value.

5.3.1 Defining Vector Quantities

Nothing special is necessary for defining vector quantities, but a formatted vector is used when invoking the value of that quantity.

```
\displacement{\mivector{3,2,-1}}
```

$\langle 3, 2, -1 \rangle$ m

5.4 First Semester Physics

The first semester of *Matter & Interactions* and indeed most traditional introductory calculus-based physics course, focuses on mechanics, dynamics, and statistical mechanics.

5.4.1 Predefined Quantities

The seven fundamental quantities are similarly defined and examples of their usage is given in the following table.

`\displacement{`⟨*magnitude*⟩`}`
Command for displacement.

```
a displacement of \displacement{5}  \\
a displacement of \displacement{\mivector{3,2,-1}}
```

a displacement of 5 m
a displacement of $\langle 3, 2, -1 \rangle$ m

\mass{⟨*magnitude*⟩}
Command for mass.

```
a mass of \mass{5}
```

a mass of 5 kg

\duration{⟨*magnitude*⟩}
Command for duration.

```
a duration of \duration{5}
```

a duration of 5 s

\current{⟨*magnitude*⟩}
Command for current.

```
a current of \current{5}
```

a current of 5 A

\temperature{⟨*magnitude*⟩}
Command for temperature.

```
a temperature of \temperature{5}
```

a temperature of 5 K

\amount{⟨*magnitude*⟩}
Command for amount.

```
an amount of \amount{5}
```

an amount of 5 mol

\luminous{⟨*magnitude*⟩}
Command for luminous intensity.

```
a luminous intensity of \luminous{5}
```

a luminous intensity of 5 cd

While we're at it, let's also go ahead and define a few non-SI units from astronomy and astrophysics.

\planeangle{⟨*magnitude*⟩}
Command for plane angle in radians.

```
a plane angle of \planeangle{5}
```
a plane angle of 5 rad

\solidangle{⟨*magnitude*⟩}
Command for solidangle.

```
a solid angle of \solidangle{5}
```
a solid angle of 5 sr

\indegrees{⟨*magnitude*⟩}
Command for plane angle in degrees.

```
a plane angle of \indegrees{5}
```
a plane angle of 5 °

\inarcminutes{⟨*magnitude*⟩}
Command for plane angle in minutes of arc.

```
an angle of \inarcminutes{5}
```
an angle of 5 ′

\inarcseconds{⟨*magnitude*⟩}
Command for plane angle in seconds of arc.

```
an angle of \inarcseconds{5}
```
an angle of 5 ″

\inFarenheit{⟨*magnitude*⟩}
Command for temperature in degrees Farenheit.

```
a temperature of \inFarenheit{68}
```
a temperature of 68 °F

\inCelsius{⟨*magnitude*⟩}
Command for temperature in degrees Celsius.

```
a temperature of \inCelsius{20}
```
a temperature of 20 °C

\ineV{⟨*magnitude*⟩}
Command for energy in electron volts.

```
an energy of \ineV{10.2}
```

an energy of 10.2 eV

\inMeVocs{⟨*magnitude*⟩}
Command for mass in MeV/c^2.

```
a mass of \inMeVocs{0.511}
```

a mass of 0.511 MeV/c^2

\inMeVoc{⟨*magnitude*⟩}
Command for momentum in MeV/c.

```
a momentum of \inMeVoc{3.6}
```

a momentum of 3.6 MeV/c

\inAU{⟨*magnitude*⟩}
Command for displacement in astronomical units.

```
a semimajor axis of \inAU{5.2}
```

a semimajor axis of 5.2 AU

\inly{⟨*magnitude*⟩}
Command for displacement in light years.

```
a distance of \inly{4.3}
```

a distance of 4.3 ly

\incyr{⟨*magnitude*⟩}
Command for displacement in light years written differently.

```
a distance of \incyr{4.3}
```

a distance of 4.3 $c \cdot$ year

\inpc{⟨*magnitude*⟩}
Command for displacement in parsecs.

```
a distance of \inpc{4.3}
```
a distance of 4.3 pc

\insolarL{⟨*magnitude*⟩}
Command for luminosity in solar multiples.

```
a luminosity of \insolarL{4.3}
```
a luminosity of $4.3\,L_{\odot}$

\insolarT{⟨*magnitude*⟩}
Command for temperature in solar multiples.

```
a temperature of \insolarT{2}
```
a temperature of $2\,T_{\odot}$

\insolarR{⟨*magnitude*⟩}
Command for radius in solar multiples.

```
a radius of \insolarR{4.3}
```
a radius of $4.3\,R_{\odot}$

\insolarM{⟨*magnitude*⟩}
Command for mass in solar multiples.

```
a mass of \insolarM{4.3}
```
a mass of $4.3\,M_{\odot}$

\insolarF{⟨*magnitude*⟩}
Command for flux in solar multiples.

```
a flux of \insolarF{4.3}
```
a flux of $4.3\,F_{\odot}$

\insolarf{⟨*magnitude*⟩}
Command for apparent flux in solar multiples.

```
an apparent flux of \insolarf{4.3}
```
an apparent flux of $4.3\,f_{\odot}$

\insolarMag{⟨*magnitude*⟩}
Command for absolute magnitude in solar multiples.

```
an absolute magnitude of \insolarMag{2}
```

an absolute magnitude of $2\,M_{\odot}$

\insolarmag{⟨*magnitude*⟩}
Command for apparent magnitude in solar multiples.

```
an apparent magnitude of \insolarmag{2}
```

an apparent magnitude of $2\,m_{\odot}$

\insolarD{⟨*magnitude*⟩}
Command for distance in solar multiples.

```
a distance of \insolarD{2}
```

a distance of $2\,D_{\odot}$

\insolard{⟨*magnitude*⟩}
Identical to \insular but uses d.

```
a distance of \insolard{2}
```

a distance of $2\,d_{\odot}$

Angles are confusing in introductory physics because sometimes we write the unit and sometimes we do not. Some concepts, such as flux, are simplified by introducing solid angle.

Now let us move on into first semester physics, defining quantities in the approximate order in which they appear in *Matter & Interactions*. Use \scin[]{} to get scientific notation, with the mantissa as the optional first argument and the exponent as the required second argument. \scin has an optional third argument that specifies a unit, but that is not needed or used in the following examples.

\velocityc{⟨*magnitude*⟩}
Command for magnitude of velocity as a fraction of c.

```
a velocity of \velocityc{0.9987} \\
a velocity of \velocityc{\mivector{0,0.9987,0}}
```

a velocity of $0.9987c$
a velocity of $\langle 0, 0.9987, 0\rangle\, c$

\velocity{⟨*magnitude*⟩}
Command for magnitude of velocity.

```
a velocity of \velocity{2.34} \\
a velocity of \velocity{\mivector{3,2,-1}}
```

a velocity of 2.34 m/s
a velocity of $\langle 3, 2, -1 \rangle$ m/s

\lorentz{⟨*magnitude*⟩}
Command for relativistic Lorentz factor.

```
a Lorentz factor of \lorentz{2.34}
```

a Lorentz factor of 2.34

\momentum{⟨*magnitude*⟩}
Command for momentum.

```
a momentum of \momentum{2.34}  \\
a momentum of \momentum{\mivector{3,2,-1}}
```

a momentum of 2.34 kg · m/s
a momentum of $\langle 3, 2, -1 \rangle$ kg · m/s

\acceleration{⟨*magnitude*⟩}
Command for acceleration.

```
an acceleration of \acceleration{2.34} \\
an acceleration of ❩
      ❨\acceleration{\mivector{3,2,-1}}
```

an acceleration of 2.34 m/s^2
an acceleration of $\langle 3, 2, -1 \rangle$ m/s^2

\impulse{⟨*magnitude*⟩}
Command for impulse.

```
an impulse of \impulse{2.34} \\
an impulse of \impulse{\mivector{3,2,-1}}
```

an impulse of 2.34 kg · m/s
an impulse of $\langle 3, 2, -1 \rangle$ kg · m/s

\force{⟨*magnitude*⟩}
Command for force.

```
a force of \force{2.34}  \\
a force of \force{\mivector{3,2,-1}}
```

a force of 2.34 N
a force of $\langle 3, 2, -1 \rangle$ N

\springstiffness{⟨*magnitude*⟩}
Command for spring stiffness.

```
a spring stiffness of \springstiffness{2.34}
```
a spring stiffness of 2.34 N/m

\springstretch{⟨*magnitude*⟩}
Command for spring stretch.

```
a spring stretch of \springstretch{2.34}
```
a spring stretch of 2.34 m

\area{⟨*magnitude*⟩}
Command for area.

```
an area of \area{2.34}
```
an area of 2.34 m^2

\volume{⟨*magnitude*⟩}
Command for volume.

```
a volume of \volume{2.34}
```
a volume of 2.34 m^3

\linearmassdensity{⟨*magnitude*⟩}
Command for linear mass density.

```
a linear mass density of \linearmassdensity{2.34}
```
a linear mass density of 2.34 kg/m

\areamassdensity{⟨*magnitude*⟩}
Command for area mass density.

```
an area mass density of \areamassdensity{2.34}
```
an area mass density of 2.34 kg/m^2

\volumemassdensity{⟨*magnitude*⟩}
Command for volume mass density.

```
a volume mass density of \volumemassdensity{2.34}
```
a volume mass density of 2.34 kg/m^3

\youngsmodulus{⟨*magnitude*⟩}
Command for Young's modulus.

```
a Young's modulus of ↩
      ↪\youngsmodulus{\scin[2.34]{9}}
```
a Young's modulus of $2.34 \times 10^{9}\,\mathrm{Pa}$

\work{⟨*magnitude*⟩}
Command for work.

```
an amount of work \work{2.34}
```
an amount of work $2.34\,\mathrm{N \cdot m}$

\energy{⟨*magnitude*⟩}
Command for energy. Work and energy have the same unit, but are conceptually different.

```
an amount of energy \energy{2.34}
```
an amount of energy $2.34\,\mathrm{N \cdot m}$

\power{⟨*magnitude*⟩}
Command for power.

```
an amount of power \power{2.34}
```
an amount of power $2.34\,\mathrm{J/s}$

\angularvelocity{⟨*magnitude*⟩}
Command for angular velocity.

```
an angular velocity of \angularvelocity{2.34}
```
an angular velocity of $2.34\,\mathrm{rad/s}$

\angularacceleration{⟨*magnitude*⟩}
Command for angular acceleration.

```
an angular acceleration of ↩
      ↪\angularacceleration{2.34}
```
an angular acceleration of $2.34\,\mathrm{rad/s^2}$

\angularmomentum{⟨*magnitude*⟩}
Command for angular momentum.

```
an angular momentum of \angularmomentum{2.34}
```
an angular momentum of $2.34\,\mathrm{kg \cdot m^2/s}$

\momentofinertia{⟨*magnitude*⟩}
Command for moment of inertia.

```
a moment of inertia of \momentofinertia{2.34}
```

a moment of inertia of $2.34\,\mathrm{kg \cdot m^2}$

\torque{⟨*magnitude*⟩}
Command for torque.

```
a torque of \torque{2.34}
```

a torque of $2.34\,\mathrm{N \cdot m}$

\entropy{⟨*magnitude*⟩}
Command for entropy.

```
an entropy of \entropy{2.34}
```

an entropy of $2.34\,\mathrm{J/K}$

\wavelength{⟨*magnitude*⟩}
Command for wavelength.

```
a wavelength of \wavelength{\scin[4.00]{-7}}
```

a wavelength of $4.00 \times 10^{-7}\,\mathrm{m}$

\wavenumber{⟨*magnitude*⟩}
Command for wavenumber.

```
a wavenumber of \wavenumber{\scin[2.50]{6}}
```

a wavenumber of $2.50 \times 10^{6}\,\mathrm{/m}$

\frequency{⟨*magnitude*⟩}
Command for frequency.

```
a frequency of \frequency{\scin[7.50]{14}}
```

a frequency of $7.50 \times 10^{14}\,\mathrm{Hz}$

\angularfrequency{⟨*magnitude*⟩}
Command for angularfrequency.

```
an angular frequency of ↴
      ↳\angularfrequency{\scin[4.70]{15}}
```

an angular frequency of 4.70×10^{15} rad/s

Two quick thoughts here. First, work and energy are similar to momentum and impulse in that they come from two different concepts. Work comes from force acting through a spatial displacement and energy is a fundamental property of matter. It is a coincidence that they have the same dimensions and thus the same unit. Second, notice that I didn't define speed. Velocity is the only quantity I can think of for which we have different names for the vector and the magnitude of the vector. I decided to put it on the same footing as momentum, acceleration, and force.

5.5 Second Semester Physics

The second semester of *Matter & Interactions* focuses on electromagnetic theory, and there are many primary and secondary quantities.

5.5.1 Predefined Quantities

\charge{⟨*magnitude*⟩}
Command for electric charge.

```
a charge of \charge{\scin[2]{-9}}
```

a charge of 2×10^{-9} C

\permittivity{⟨*magnitude*⟩}
Command for permittivity.

```
a permittivity of \permittivity{\scin[9]{-12}}
```

a permittivity of 9×10^{-12} C^2/N $\cdot$ m^2

\electricdipolemoment{⟨*magnitude*⟩}
Command for electric dipole moment.

```
an electric dipole moment of ↴
      ↳\electricdipolemoment{\scin[2]{5}}
```

an electric dipole moment of 2×10^{5} C $\cdot$ m

\permeability{⟨*magnitude*⟩}
Command for permeability.

```
a permeability of \permeability{\scin[4\pi]{-7}}
```

a permeability of $4\pi \times 10^{-7}$ T $\cdot$ m/A

\magneticfield{⟨*magnitude*⟩}
Command for magnetic field (also called magnetic induction).

```
a magnetic field of \magneticfield{1.25}
```

a magnetic field of $1.25\,\mathrm{N/C \cdot (m/s)}$

\cmagneticfield{⟨*magnitude*⟩}
Command for product of c and magnetic field. This quantity is convenient for symmetry.

```
a magnetic field of \cmagneticfield{1.25}
```

a magnetic field of $1.25\,\mathrm{N/C}$

\linearchargedensity{⟨*magnitude*⟩}
Command for linear charge density.

```
a linear charge density of ↵
      ↳\linearchargedensity{\scin[4.5]{-3}}
```

a linear charge density of $4.5 \times 10^{-3}\,\mathrm{C/m}$

\areachargedensity{⟨*magnitude*⟩}
Command for area charge density.

```
an area charge density of \areachargedensity{1.25}
```

an area charge density of $1.25\,\mathrm{C/m^2}$

\volumechargedensity{⟨*magnitude*⟩}
Command for volume charge density.

```
a volume charge density of ↵
      ↳\volumechargedensity{1.25}
```

a volume charge density of $1.25\,\mathrm{C/m^3}$

\mobility{⟨*magnitude*⟩}
Command for electron mobility.

```
a mobility of \areachargedensity{\scin[4.5]{-3}}
```

a mobility of $4.5 \times 10^{-3}\,\mathrm{C/m^2}$

\numberdensity{⟨*magnitude*⟩}
Command for electron number density.

```
a number density of \numberdensity{\scin[2]{18}}
```
a number density of $2 \times 10^{18}\,/\mathrm{m}^{3}$

\polarizability{⟨*magnitude*⟩}
Command for polarizability.

```
a polarizability of ↩
      ↪\polarizability{\scin[1.96]{-40}}
```
a polarizability of $1.96 \times 10^{-40}\,\mathrm{C \cdot m}/\left(\mathrm{N/C}\right)$

\electricpotential{⟨*magnitude*⟩}
Command for electric potential.

```
an electric potential of \polarizability{1.5}
```
an electric potential of $1.5\,\mathrm{C \cdot m}/\left(\mathrm{N/C}\right)$

\emf{⟨*magnitude*⟩}
Command for emf.

```
an emf of \emf{1.5}
```
an emf of $1.5\,\mathrm{V}$

\dielectricconstant{⟨*magnitude*⟩}
Command for dielectric constant.

```
a dielectric constant of \dielectricconstant{1.5}
```
a dielectric constant of 1.5

\indexofrefraction{⟨*magnitude*⟩}
Command for index of refraction.

```
an index of refraction of \indexofrefraction{1.5}
```
an index of refraction of 1.5

\relativepermittivity{⟨*magnitude*⟩}
Command for relative permittivity.

```
a relative permittivity of ↩
      ↪\relativepermittivity{0.9}
```
a relative permittivity of 0.9

\relativepermeability{⟨*magnitude*⟩}
Command for relative permeability.

```
a relative permeability of ↩
      ↪\relativepermeability{0.9}
```

a relative permeability of 0.9

\energydensity{⟨*magnitude*⟩}
Command for energy density.

```
an energy density of \energydensity{1.25}
```

an energy density of $1.25\,\mathrm{J/m^3}$

\electroncurrent{⟨*magnitude*⟩}
Command for electron current.

```
an electron current of ↩
      ↪\electroncurrent{\scin[2]{18}}
```

an electron current of $2 \times 10^{18}\,\mathrm{e/s}$

\conventionalcurrent{⟨*magnitude*⟩}
Command for conventional current.

```
a conventional current of ↩
      ↪\conventionalcurrent{0.003}
```

a conventional current of 0.003 A

\magneticdipolemoment{⟨*magnitude*⟩}
Command for magnetic dipole moment.

```
a magnetic dipole moment of ↩
      ↪\magneticdipolemoment{1.25}
```

a magnetic dipole moment of $1.25\,\mathrm{A \cdot m^2}$

\currentdensity{⟨*magnitude*⟩}
Command for current density.

```
a current density of \currentdensity{1.25}
```

a current density of $1.25\,\mathrm{A/m^2}$

\electricflux{⟨*magnitude*⟩}
Command for electric flux.

```
an electric flux of \electricflux{1.25}
```
an electric flux of $1.25\,\mathrm{N \cdot m^2/C}$

\magneticflux{⟨*magnitude*⟩}
Command for magnetic flux.

```
a magnetic flux of \magneticflux{1.25}
```
a magnetic flux of $1.25\,\mathrm{T \cdot m^2}$

\capacitance{⟨*magnitude*⟩}
Command for capacitance.

```
a capacitance of \capacitance{1.00}
```
a capacitance of $1.00\,\mathrm{C/V}$

\inductance{⟨*magnitude*⟩}
Command for inductance.

```
an inductance of \inductance{1.00}
```
an inductance of $1.00\,\mathrm{V \cdot s/A}$

\conductivity{⟨*magnitude*⟩}
Command for conductivity.

```
a conductivity of \conductivity{1.25}
```
a conductivity of $1.25\,\left(\mathrm{A/m^2}\right)\,/\,\left(\mathrm{V/m}\right)$

\resistivity{⟨*magnitude*⟩}
Command for resistivity.

```
a resistivity of \resistivity{1.25}
```
a resistivity of $1.25\,\left(\mathrm{V/m}\right)\,/\,\left(\mathrm{A/m^2}\right)$

\resistance{⟨*magnitude*⟩}
Command for resistance.

```
a resistance of \resistance{\scin[1]{6}}
```
a resistance of $1 \times 10^{6}\,\Omega$

\conductance{⟨*magnitude*⟩}
Command for conductance.

`a conductance of \conductance{\scin[1]{6}}`	a conductance of $1 \times 10^{6}\,\mathrm{S}$

\magneticcharge{⟨*magnitude*⟩}
Command for magnetic charge, in case it actually exists.

`a magnetic charge of \magneticcharge{1.25}`	a magnetic charge of $1.25\,\mathrm{m \cdot A}$

\energyflux{⟨*magnitude*⟩}
Command for energy flux.

`an energy flux of \energyflux{\scin[4]{26}}`	an energy flux of $4 \times 10^{26}\,\mathrm{W/m^2}$

5.6 Further Words on Units

As you recall, when a new scalar or vector is defined, a host of other commands is also automatically defined. Consider momentum. The following commands are defined:

`\momentum{3}`	$3\,\mathrm{kg \cdot m/s}$	unit determined by global options
`\momentumbaseunit{3}`	$3\,\mathrm{m \cdot kg \cdot s^{-1}}$	quantity with base unit
`\momentumdrvdunit{3}`	$3\,\mathrm{N \cdot s}$	quantity with derived unit
`\momentumtradunit{3}`	$3\,\mathrm{kg \cdot m/s}$	quantity with traditional unit
`\momentumvalue{3}`	3	selects numerical value of quantity
`\momentumonlybaseunit`	$\mathrm{m \cdot kg \cdot s^{-1}}$	selects only base unit
`\momentumonlydrvdunit`	$\mathrm{N \cdot s}$	selects only derived unit
`\momentumonlytradunit`	$\mathrm{kg \cdot m/s}$	selects only traditional unit

The form of a quantity's unit can be changed on the fly regardless of the global format determined by **baseunits** and **drvdunits**. One way, as illustrated in the table above, is to append `baseunit`, `drvdunit`, `tradunit` to the quantity's name, and this will override the global options for that instance.

A second way is to use the commands that change a quantity's unit on the fly.

\hereusebaseunit{⟨*magnitude*⟩}
Command for using base units in place.

`a momentum of \hereusebaseunit{\momentum{3}}`	a momentum of $3\,\mathrm{m \cdot kg \cdot s^{-1}}$

\hereusedrvdunit{⟨*magnitude*⟩}
Command for using derived units in place.

```
a momentum of \hereusedrvdunit{\momentum{3}}
```
a momentum of $3\,\mathrm{N \cdot s}$

\hereusetradunit{⟨*magnitude*⟩}
Command for using traditional units in place.

```
a momentum of \hereusetradunit{\momentum{3}}
```
a momentum of $3\,\mathrm{kg \cdot m/s}$

A third way is to use the environments that change a quantity's unit for the duration of the environment.

\begin{usebaseunit}
⟨*environment content*⟩
\end{usebaseunit}
Environment for using base units.

```
\begin{usebaseunit}
  \momentum{3}
\end{usebaseunit}
```
$3\,\mathrm{m \cdot kg \cdot s^{-1}}$

\begin{usedrvdunit}
⟨*environment content*⟩
\end{usedrvdunit}
Environment for using derived units.

```
\begin{usedrvdunit}
  \momentum{3}
\end{usedrvdunit}
```
$3\,\mathrm{N \cdot s}$

\begin{usetradunit}
⟨*environment content*⟩
\end{usetradunit}
Environment for using traditional units.

```
\begin{usetradunit}
  \momentum{3}
\end{usetradunit}
```
$3\,\mathrm{kg \cdot m/s}$

A fourth way is to use the three global switches that perpetually change the default unit. **It's important to remember that these switches override the global options for the rest of the document or until overridden by one of the other two switches.**

\perpusebaseunit
Command for perpetually using base units.

\perpusedrvdunit{⟨*magnitude*⟩}
Command for perpetually using derived units..

\perpusetradunit{⟨*magnitude*⟩}
Command for perpetually using traditional units..

5.7 Symbolic Expressions with Vectors

5.7.1 Basic Vectors

\vect{⟨*kernel*⟩}
Symbol for a vector quantity.

```
\vect{p}
```

$\vec{p}$

\magvect{⟨*kernel*⟩}
Symbol for magnitude of a vector quantity.

```
\magvect{p}
```

$|\vec{p}|$

\dirvect{⟨*kernel*⟩}
Symbol for direction of a vector quantity.

```
\dirvect{p}
```

$\hat{p}$

\mivector[⟨*printeddelimiter*⟩]{⟨*commadelimitedlistofcomps*⟩}[⟨*unit*⟩]
Generic workhorse command for vectors formatted as in *Matter & Interactions*.

```
\begin{align*}
\msub{u}{\mu} &= ⤸
      ⤹\mivector{\ezero,\eone,\etwo,\ethree} \\
\vect{v} &= ⤸
      ⤹\mivector{1,3,5}[\velocityonlytradunit]  ⤸
      ⤹  \\
\vect{E} &= \mivector{\oofpezmathsymbol ⤸
      ⤹\frac{Q}{\msup{x}{2}},0,0}
\end{align*}
```

$$u_{\mu} = \left\langle \mathbf{e}_0, \mathbf{e}_1, \mathbf{e}_2, \mathbf{e}_3 \right\rangle$$
$$\vec{v} = \langle 1, 3, 5 \rangle \text{ m/s}$$
$$\vec{E} = \left\langle \frac{1}{4\pi\epsilon_\circ}\frac{Q}{x^2}, 0, 0 \right\rangle$$

\ncompszerovect
Symbol for the zero vector expressed in components. Deprecated. Use \mivector instead.

```
\ncompszerovect
```
$\langle 0, 0, 0 \rangle$

\symvect{⟨*listofcomps*⟩}
Command for a vector with symbolic components. Deprecated. Use \mivector instead.

```
\symvect{\magvect{E}\cos\theta,
  \magvect{E}\sin\theta,0}
```
$\left\langle \left|\vec{E}\right| \cos\theta, \left|\vec{E}\right| \sin\theta, 0 \right\rangle$

\ncompsvect{⟨*listofcomps*⟩}[⟨*unit*⟩]
Command for a vector with numerical components and an optional unit. Deprecated. Use \mivector instead.

```
\ncompsvect{3,4,6}[\velocityonlytradunit]
```
$\langle 3, 4, 6 \rangle$ m/s

\magvectncomps{⟨*listofcomps*⟩}[⟨*unit*⟩]
Expression for a vector's magnitude with numerical components and an optional unit.

```
\magvectncomps{3.12,4.04,6.73}[\velocityonlytradunit]
```
$\sqrt{(3.12 \text{ m/s})^2 + (4.04 \text{ m/s})^2 + (6.73 \text{ m/s})^2}$

\scompsvect{⟨*kernel*⟩}
Expression for a vector's symbolic components.

```
\scompsvect{E}
```
$\left\langle E_x, E_y, E_z \right\rangle$

\compvect{⟨*kernel*⟩}{⟨*component*⟩}
Isolates one of a vector's symbolic components.

```
\compvect{E}{y}
```
E_y

\magvectscomps{⟨*kernel*⟩}
Expression for a vector's magnitude in terms of its symbolic components.

```
\magvectscomps{B}
```
$\sqrt{B_x^2 + B_y^2 + B_z^2}$

5.7.2 Position Vectors

\scompspos
Expression for a position vector's traditional symbolic components.

`\scompspos`	$\langle x, y, z \rangle$

\comppos{⟨*component*⟩}
Isolates one symbolic component of a position vector.

`\comppos{z}`	z

5.7.3 Differentials and Derivatives of Vectors

\dvect{⟨*kernel*⟩}
Symbol for the differential of a vector.

`a change \dvect{E} in electric field`	a change $\mathrm{d}\vec{E}$ in electric field

\Dvect{⟨*kernel*⟩}
Identical to `\dvect` but uses Δ.

`a change \Dvect{E} in electric field`	a change $\Delta\vec{E}$ in electric field

\dirdvect{⟨*kernel*⟩}
Symbol for the direction of a vector's differential.

`the direction \dirdvect{E} of the change`	the direction $\widehat{\mathrm{d}\vec{E}}$ of the change

\dirDvect{⟨*kernel*⟩}
Identical to `\dirdvect` but uses Δ.

`the direction \dirDvect{E} of the change`	the direction $\widehat{\Delta\vec{E}}$ of the change

\ddirvect{⟨*kernel*⟩}
Symbol for the differential of a vector's direction.

```
the change \ddirvect{E} in the direction
```

the change $\mathrm{d}\widehat{E}$ in the direction

\Ddirvect{⟨*kernel*⟩}
Identical to \ddirvect but uses Δ.

```
the direction \Ddirvect{E} of the change
```

the direction $\Delta\widehat{E}$ of the change

\magdvect{⟨*kernel*⟩}
Symbol for the magnitude of a vector's differential.

```
the magnitude \magdvect{E} of the change
```

the magnitude $\left|\mathrm{d}\vec{E}\right|$ of the change

\magDvect{⟨*kernel*⟩}
Identical to \magdvect but uses Δ.

```
the magnitude \magDvect{E} of the change
```

the magnitude $\left|\Delta\vec{E}\right|$ of the change

\dmagvect{⟨*kernel*⟩}
Symbol for the differential of a vector's magnitude.

```
the change \dmagvect{E} in the magnitude
```

the change $\mathrm{d}\left|\vec{E}\right|$ in the magnitude

\Dmagvect{⟨*kernel*⟩}
Identical to \dmagvect but uses Δ.

```
the change \Dmagvect{E} in the magnitude
```

the change $\Delta\left|\vec{E}\right|$ in the magnitude

\scompsdvect{⟨*kernel*⟩}
Symbolic components of a vector.

`the vector \scompsdvect{E}`	the vector $\left\langle \mathrm{d}E_x, \mathrm{d}E_y, \mathrm{d}E_z \right\rangle$

\scompsDvect{⟨*kernel*⟩}
Identical to \scompsdvect but uses Δ.

`the vector \scompsDvect{E}`	the vector $\left\langle \Delta E_x, \Delta E_y, \Delta E_z \right\rangle$

\compdvect{⟨*kernel*⟩}{⟨*component*⟩}
Isolates one symbolic component of a vector's differential.

`the \compdvect{E}{y} component of the change`	the $\mathrm{d}E_y$ component of the change

\compDvect{⟨*kernel*⟩}{⟨*component*⟩}
Identical to \compdvect but uses Δ.

`the \compDvect{E}{y} component of the change`	the ΔE_y component of the change

\scompsdpos
Symbolic components of a position vector.

`the change in position \scompsdpos`	the change in position $\langle \mathrm{d}x, \mathrm{d}y, \mathrm{d}z \rangle$

\scompsDpos
Identical to \scompsdpos but uses Δ.

`the change in position \scompsDpos`	the change in position $\langle \Delta x, \Delta y, \Delta z \rangle$

\compdpos{⟨*component*⟩}
Isolates one component of a position vector's differential.

`the component \compdpos{z} of the change`	the component $\mathrm{d}z$ of the change

\compDpos{⟨*component*⟩}
Identical to \compdpos but uses Δ.

`the component \compDpos{z} of the change`	the component Δz of the change

\dervect{⟨*kernel*⟩}{⟨*indvar*⟩}
Symbol for a vector's derivative with respect to an independent variable.

`the derivative \dervect{E}{t}`	the derivative $\frac{\mathrm{d}\vec{E}}{\mathrm{d}t}$

\Dervect{⟨*kernel*⟩}{⟨*indvar*⟩}
Identical to \dervect but uses Δ.

`the derivative \Dervect{E}{t}`	the derivative $\frac{\Delta\vec{E}}{\Delta t}$

\dermagvect{⟨*kernel*⟩}{⟨*indvar*⟩}
Symbol for the derivative of a vector's magnitude with respect to an independent variable.

`the derivative \dermagvect{E}{t}`	the derivative $\frac{\mathrm{d}\left\vert\vec{E}\right\vert}{\mathrm{d}t}$

\Dermagvect{⟨*kernel*⟩}{⟨*indvar*⟩}
Identical to \dermagvect but uses Δ.

`the derivative \Dermagvect{E}{t}`	the derivative $\frac{\Delta\left\vert\vec{E}\right\vert}{\Delta t}$

\scompsdervect{⟨*kernel*⟩}{⟨*indvar*⟩}
Symbolic components of a vector's derivative with respect to an independent variable.

`the derivative \scompsdervect{E}{t}`	the derivative $\left\langle \frac{\mathrm{d}E_x}{\mathrm{d}t}, \frac{\mathrm{d}E_y}{\mathrm{d}t}, \frac{\mathrm{d}E_z}{\mathrm{d}t} \right\rangle$

\scompsDervect{⟨*kernel*⟩}{⟨*indvar*⟩}
Identical to \scompsdervect but uses Δ.

`the derivative \scompsdervect{E}{t}`	the derivative $\left\langle \frac{\mathrm{d}E_x}{\mathrm{d}t}, \frac{\mathrm{d}E_y}{\mathrm{d}t}, \frac{\mathrm{d}E_z}{\mathrm{d}t} \right\rangle$

\compdervect{⟨*kernel*⟩}{⟨*component*⟩}{⟨*indvar*⟩}
Isolates one component of a vector's derivative with respect to an independent variable.

`the derivative \compdervect{E}{y}{t}`	the derivative $\frac{\mathrm{d}E_y}{\mathrm{d}t}$

\compDervect{⟨*kernel*⟩}{⟨*component*⟩}{⟨*indvar*⟩}
Identical to \compdervect but uses Δ.

`the derivative \compDervect{E}{y}{t}`	the derivative $\frac{\Delta E_y}{\Delta t}$

\magdervect{⟨*kernel*⟩}{⟨*indvar*⟩}
Symbol for the magnitude of a vector's derivative with respect to an independent variable.

`the derivative \magdervect{E}{t}`	the derivative $\left\lvert \frac{\mathrm{d}\vec{E}}{\mathrm{d}t} \right\rvert$

\magDervect{⟨*kernel*⟩}{⟨*indvar*⟩}
Identical to \magdervect but uses Δ.

`the derivative \magDervect{E}{t}`	the derivative $\left\lvert \frac{\Delta\vec{E}}{\Delta t} \right\rvert$

\scompsderpos{⟨*indvar*⟩}
Symbolic components of a position vector's derivative with respect to an independent variable.

`the derivative \scompsderpos{t}`	the derivative $\left\langle \frac{\mathrm{d}x}{\mathrm{d}t}, \frac{\mathrm{d}y}{\mathrm{d}t}, \frac{\mathrm{d}z}{\mathrm{d}t} \right\rangle$

\scompsDerpos{⟨*indvar*⟩}
Identical to \scompsderpos but uses Δ.

`the derivative \scompsDerpos{t}`	the derivative $\left\langle \frac{\Delta x}{\Delta t}, \frac{\Delta y}{\Delta t}, \frac{\Delta z}{\Delta t} \right\rangle$

\compderpos{⟨*component*⟩}{⟨*indvar*⟩}
Isolates one component of a vector's derivative with respect to an independent variable.

`the derivative \compderpos{z}{t}`	the derivative $\frac{\mathrm{d}z}{\mathrm{d}t}$

\compDerpos{⟨*component*⟩}{⟨*indvar*⟩}
Identical to \compderpos but uses Δ.

`the derivative \compDerpos{z}{t}`	the derivative $\frac{\Delta z}{\Delta t}$

5.7.4 Naming Conventions You Have Seen

By now you probably understand that commands are named as closely as possible to the way you would say or write what you want. Every time you see `comp` you should think of a single component. Every time you see `scomps` you should think of a set of symbolic components. Every time you see `der` you should think derivative. Every time you see `dir` you should think direction. I have tried to make the names simple both logically and lexically.

5.7.5 Subscripted or Indexed Vectors

Now we have commands for vectors that carry subscripts or indices, usually to identify an object or something similar. Basically, `vect` becomes `vectsub` and `pos` becomes `possub`. Ideally, a subscript should not contain mathematical symbols. However, if you wish to do so, just wrap the symbol with `\(...\)` as you normally would. All of the commands for non-subscripted vectors are available for subscripted vectors.

\vectsub{⟨*kernel*⟩}{⟨*sub*⟩}
Symbol for a subscripted vector.

`the vector \vectsub{p}{ball}`	the vector $\vec{p}_{\mathrm{ball}}$

\magvectsub{⟨*kernel*⟩}{⟨*sub*⟩}
Symbol for a subscripted vector's direction.

```
the direction \dirvectsub{p}{ball}
```
the direction $\widehat{p}_{\mathrm{ball}}$

\dirvectsub{⟨*kernel*⟩}{⟨*sub*⟩}
Symbol for a subscripted vector's magnitude.

```
the magnitude \magvectsub{p}{ball}
```
the magnitude $\left|\vec{p}_{\mathrm{ball}}\right|$

\scompsvectsub{⟨*kernel*⟩}{⟨*sub*⟩}
Symbolic components of a subscripted vector.

```
the vector \scompsvectsub{p}{ball}
```
the vector $\left\langle p_{x,\mathrm{ball}}, p_{y,\mathrm{ball}}, p_{z,\mathrm{ball}} \right\rangle$

\compvectsub{⟨*kernel*⟩}{⟨*component*⟩}{⟨*sub*⟩}
Isolates one component of a subscripted vector.

```
the component \compvectsub{p}{z}{ball}
```
the component $p_{z,\mathrm{ball}}$

\magvectsubscomps{⟨*kernel*⟩}{⟨*sub*⟩}
Expression for a subscripted vector's magnitude in terms of symbolic components.

```
the magnitude \magvectsubscomps{p}{ball}
```
the magnitude $\sqrt{p_{x,\mathrm{ball}}^2 + p_{y,\mathrm{ball}}^2 + p_{z,\mathrm{ball}}^2}$

\scompspossub{⟨*sub*⟩}
Symbolic components of a subscripted position vector.

```
the vector \scompspossub{ball}
```
the vector $\left\langle x_{\mathrm{ball}}, y_{\mathrm{ball}}, z_{\mathrm{ball}} \right\rangle$

\comppossub{⟨*component*⟩}{⟨*sub*⟩}
Isolates one component of a subscripted position vector.

```
the component \comppossub{x}{ball}
```
the component x_{ball}

\dvectsub{⟨*kernel*⟩}{⟨*sub*⟩}
Differential of a subscripted vector.

`the change \dvectsub{p}{ball}`	the change $\mathrm{d}\vec{p}_{\mathrm{ball}}$

\Dvectsub{⟨*kernel*⟩}{⟨*sub*⟩}
Identical to `\dvectsub` but uses Δ.

`the change \Dvectsub{p}{ball}`	the change $\Delta\vec{p}_{\mathrm{ball}}$

\scompsdvectsub{⟨*kernel*⟩}{⟨*sub*⟩}
Symbolic components of a subscripted vector's differential.

`the vector \scompsdvectsub{p}{ball}`	the vector $\left\langle \mathrm{d}p_{x,\mathrm{ball}}, \mathrm{d}p_{y,\mathrm{ball}}, \mathrm{d}p_{z,\mathrm{ball}} \right\rangle$

\scompsDvectsub{⟨*kernel*⟩}{⟨*sub*⟩}
Identical to `\scompsdvectsub` but uses Δ.

`the vector \scompsDvectsub{p}{ball}`	the vector $\left\langle \Delta p_{x,\mathrm{ball}}, \Delta p_{y,\mathrm{ball}}, \Delta p_{z,\mathrm{ball}} \right\rangle$

\compdvectsub{⟨*kernel*⟩}{⟨*component*⟩}{⟨*sub*⟩}
Isolates one component of a subscripted vector's differential.

`the component \compdvectsub{p}{y}{ball}`	the component $\mathrm{d}p_{y,\mathrm{ball}}$

\compDvectsub{⟨*kernel*⟩}{⟨*component*⟩}{⟨*sub*⟩}
Identical to `\compdvectsub` but uses Δ.

`the component \compDvectsub{p}{y}{ball}`	the component $\Delta p_{y,\mathrm{ball}}$

\scompsdpossub{⟨*sub*⟩}
Symbolic components of a subscripted position vector's differential.

```
the vector \scompsdpossub{ball}
```
the vector $\left\langle \mathrm{d}x_{\mathrm{ball}}, \mathrm{d}y_{\mathrm{ball}}, \mathrm{d}z_{\mathrm{ball}} \right\rangle$

\scompsDpossub{⟨*sub*⟩}
Identical to \scopmsdpossub but uses Δ.

```
the vector \scompsDpossub{ball}
```
the vector $\left\langle \Delta x_{\mathrm{ball}}, \Delta y_{\mathrm{ball}}, \Delta z_{\mathrm{ball}} \right\rangle$

\compdpossub{⟨*component*⟩}{⟨*sub*⟩}
Isolates one component of a subscripted position vector's differential.

```
the component \compdpossub{x}{ball}
```
the component $\mathrm{d}x_{\mathrm{ball}}$

\compDpossub{⟨*component*⟩}{⟨*sub*⟩}
Identical to \compdpossub but uses Δ.

```
the component \compDpossub{x}{ball}
```
the component Δx_{ball}

\dervectsub{⟨*kernel*⟩}{⟨*sub*⟩}{⟨*indvar*⟩}
Symbol for derivative of a subscripted vector with respect to an independent variable.

```
the derivative \dervectsub{p}{ball}{t}
```
the derivative $\dfrac{\mathrm{d}\vec{p}_{\mathrm{ball}}}{\mathrm{d}t}$

\Dervectsub{⟨*kernel*⟩}{⟨*sub*⟩}{⟨*indvar*⟩}
Identical to \dervectsub but uses Δ.

```
the derivative \Dervectsub{p}{ball}{t}
```
the derivative $\dfrac{\Delta\vec{p}_{\mathrm{ball}}}{\Delta t}$

\dermagvectsub{⟨*kernel*⟩}{⟨*sub*⟩}{⟨*indvar*⟩}
Symbol for the derivative of a subscripted vector's magnitude with respect to an independent variable.

```
the derivative \dermagvectsub{E}{ball}{t}
```
the derivative $\dfrac{\mathrm{d}\left|\vec{E}_{\mathrm{ball}}\right|}{\mathrm{d}t}$

\Dermagvectsub{⟨*kernel*⟩}{⟨*sub*⟩}{⟨*indvar*⟩}
Identical to \dermagvectsub but uses Δ.

```
the derivative \Dermagvectsub{E}{ball}{t}
```

the derivative $\frac{\Delta\left|\vec{E}_{\mathrm{ball}}\right|}{\Delta t}$

\scompsdervectsub{⟨*kernel*⟩}{⟨*sub*⟩}{⟨*indvar*⟩}
Symbolic components of a subscripted vector's derivative with respect to an independent variable.

```
the vector \scompsdervectsub{p}{ball}{t}
```

the vector $\left\langle \frac{\mathrm{d}p_{x,\mathrm{ball}}}{\mathrm{d}t}, \frac{\mathrm{d}p_{y,\mathrm{ball}}}{\mathrm{d}t}, \frac{\mathrm{d}p_{z,\mathrm{ball}}}{\mathrm{d}t} \right\rangle$

\scompsDervectsub{⟨*kernel*⟩}{⟨*sub*⟩}{⟨*indvar*⟩}
Identical to \scompsdervectsub but uses Δ.

```
the vector \scompsDervectsub{p}{ball}{t}
```

the vector $\left\langle \frac{\Delta p_{x,\mathrm{ball}}}{\Delta t}, \frac{\Delta p_{y,\mathrm{ball}}}{\Delta t}, \frac{\Delta p_{z,\mathrm{ball}}}{\Delta t} \right\rangle$

\compdervectsub{⟨*kernel*⟩}{⟨*component*⟩}{⟨*sub*⟩}{⟨*indvar*⟩}
Isolates one component of a subscripted vector's derivative with respect to an independent variable.

```
the component \compdervectsub{p}{y}{ball}{t}
```

the component $\frac{\mathrm{d}p_{y,\mathrm{ball}}}{\mathrm{d}t}$

\compDervectsub{⟨*kernel*⟩}{⟨*component*⟩}{⟨*sub*⟩}{⟨*indvar*⟩}
Identical to \compdervectsub but uses Δ.

```
the component \compDervectsub{p}{y}{ball}{t}
```

the component $\frac{\Delta p_{y,\mathrm{ball}}}{\Delta t}$

\magdervectsub{⟨*kernel*⟩}{⟨*sub*⟩}{⟨*indvar*⟩}
Symbol for magnitude of a subscripted vector's derivative with respect to an independent variable.

```
the derivative \magdervectsub{p}{ball}{t}
```

the derivative $\left|\frac{\mathrm{d}\vec{p}_{\mathrm{ball}}}{\mathrm{d}t}\right|$

\magDervectsub{⟨*kernel*⟩}{⟨*sub*⟩}{⟨*indvar*⟩}
Identical to \magdervectsub but uses Δ.

`the derivative \magDervectsub{p}{ball}{t}`	the derivative $\left\lvert \frac{\Delta \vec{p}_{\text{ball}}}{\Delta t} \right\rvert$

\scompsderpossub{⟨*sub*⟩}{⟨*indvar*⟩}
Symbolic components of a subscripted position vector's derivative with respect to an independent variable.

`the vector \scompsderpossub{ball}{t}`	the vector $\left\langle \frac{\mathrm{d}x_{\text{ball}}}{\mathrm{d}t}, \frac{\mathrm{d}y_{\text{ball}}}{\mathrm{d}t}, \frac{\mathrm{d}z_{\text{ball}}}{\mathrm{d}t} \right\rangle$

\scompsDerpossub{⟨*sub*⟩}{⟨*indvar*⟩}
Identical to \scompsderpossub but uses Δ.

`the vector \scompsDerpossub{ball}{t}`	the vector $\left\langle \frac{\Delta x_{\text{ball}}}{\Delta t}, \frac{\Delta y_{\text{ball}}}{\Delta t}, \frac{\Delta z_{\text{ball}}}{\Delta t} \right\rangle$

\compderpossub{⟨*component*⟩}{⟨*sub*⟩}{⟨*indvar*⟩}
Isolates one component of a subscripted position vector's derivative with respect to an independent variable.

`the component \compderpossub{y}{ball}{t}`	the component $\frac{\mathrm{d}y_{\text{ball}}}{\mathrm{d}t}$

\compDerpossub{⟨*component*⟩}{⟨*sub*⟩}{⟨*indvar*⟩}
Identical to \compderpossub but uses Δ.

`the component \compDerpossub{y}{ball}{t}`	the component $\frac{\Delta y_{\text{ball}}}{\Delta t}$

5.7.6 Relative Vectors

Sometimes it's convenient to think of the position, velocity, momentum, or force of/on one thing relative to/due to another thing.

\relpos{⟨*sub*⟩}
Symbol for relative position.

`the vector \relpos{12}`	the vector $\vec{r}_{12}$

`\relvel{`⟨*sub*⟩`}`
Symbol for relative velocity.

`the vector \relvel{12}`	the vector $\vec{v}_{12}$

`\relmom{`⟨*sub*⟩`}`
Symbol for relative momentum.

`the vector \relmom{12}`	the vector $\vec{p}_{12}$

`\relfor{`⟨*sub*⟩`}`
Symbol for relative force.

`the vector \relfor{12}`	the vector $\vec{F}_{12}$

5.7.7 Expressions Containing Dots

Now we get to commands that will save you many, many keystrokes. All of the naming conventions documented in earlier commands still apply. There are some new ones though. Every time you see `dot` you should think *dot product*. When you see `dots` you should think *dot product in terms of symbolic components*. When you see `dote` you should think *dot product expanded as a sum*. These, along with the previous naming conventions, handle many dot product expressions.

`\vectdotvect{`⟨*kernel1*⟩`}{`⟨*kernel2*⟩`}`
Symbol for dot of two vectors as a single symbol.

`\vectdotvect{\vect{F}}{\vect{v}}`	$\vec{F} \bullet \vec{v}$

`\vectdotsvect{`⟨*kernel1*⟩`}{`⟨*kernel2*⟩`}`
Symbol for dot of two vectors with symbolic components.

`\vectdotsvect{F}{v}`	$\left\langle F_x, F_y, F_z \right\rangle \bullet \left\langle v_x, v_y, v_z \right\rangle$

\vectdotevect{⟨*kernel1*⟩}{⟨*kernel2*⟩}
Symbol for dot of two vectors as an expanded sum.

`\vectdotevect{F}{v}`	$F_x\,v_x + F_y\,v_y + F_z\,v_z$

\vectdotspos{⟨*kernel*⟩}
Dot of a vector and a position vector with symbolic components.

`\vectdotspos{F}`	$\left\langle F_x, F_y, F_z \right\rangle \bullet \langle x, y, z \rangle$

\vectdotepos{⟨*kernel*⟩}
Dot of a vector and a position vector as an expanded sum.

`\vectdotepos{F}`	$F_x\,x + F_y\,y + F_z\,z$

\vectdotsdvect{⟨*kernel1*⟩}{⟨*kernel2*⟩}
Dot of a vector a vector's differential with symbolic components.

`\vectdotsdvect{F}{r}`	$\left\langle F_x, F_y, F_z \right\rangle \bullet \left\langle \mathrm{d}r_x, \mathrm{d}r_y, \mathrm{d}r_z \right\rangle$

\vectdotsDvect{⟨*kernel1*⟩}{⟨*kernel2*⟩}
Identical to `\vectdotsdvect` but uses Δ.

`\vectdotsDvect{F}{r}`	$\left\langle F_x, F_y, F_z \right\rangle \bullet \left\langle \Delta r_x, \Delta r_y, \Delta r_z \right\rangle$

\vectdotedvect{⟨*kernel1*⟩}{⟨*kernel2*⟩}
Dot of a vector a vector's differential as an expanded sum.

`\vectdotedvect{F}{r}`	$F_x\,\mathrm{d}r_x + F_y\,\mathrm{d}r_y + F_z\,\mathrm{d}r_z$

\vectdoteDvect{⟨*kernel1*⟩}{⟨*kernel2*⟩}
Identical to `\vectdotedvect` but uses Δ.

`\vectdoteDvect{F}{r}`	$F_x\,\Delta r_x + F_y\,\Delta r_y + F_z\,\Delta r_z$

\vectdotsdpos{⟨*kernel*⟩}
Dot of a vector and a position vector's differential with symbolic components.

`\vectdotsdpos{F}`	$\left\langle F_x, F_y, F_z \right\rangle \bullet \langle \mathrm{d}x, \mathrm{d}y, \mathrm{d}z \rangle$

\vectdotsDpos{⟨*kernel*⟩}
Identical to `\vectdotsdpos` but uses Δ.

`\vectdotsDpos{F}`	$\left\langle F_x, F_y, F_z \right\rangle \bullet \langle \Delta x, \Delta y, \Delta z \rangle$

\vectdotedpos{⟨*kernel*⟩}
Dot of a vector and a position vector's differential as an expanded sum.

`\vectdotedpos{F}`	$F_x\,\mathrm{d}x + F_y\,\mathrm{d}y + F_z\,\mathrm{d}z$

\vectdoteDpos{⟨*kernel*⟩}
Identical to `\vectdotedpos` but uses Δ.

`\vectdoteDpos{F}`	$F_x\,\Delta x + F_y\,\Delta y + F_z\,\Delta z$

\vectsubdotsvectsub{⟨*kernel1*⟩}{⟨*sub1*⟩}{⟨*kernel2*⟩}{⟨*sub2*⟩}
Dot of two subscripted vectors with symbolic components.

`\vectsubdotsvectsub{F}{grav}{r}{ball}`	$\left\langle F_{x,\mathrm{grav}}, F_{y,\mathrm{grav}}, F_{z,\mathrm{grav}} \right\rangle \bullet \left\langle r_{x,\mathrm{ball}}, r_{y,\mathrm{ball}}, r_{z,\mathrm{ball}} \right\rangle$

\vectsubdotevectsub{⟨*kernel1*⟩}{⟨*sub1*⟩}{⟨*kernel2*⟩}{⟨*sub2*⟩}
Dot of two subscripted vectors as an expanded sum.

`\vectsubdotevectsub{F}{grav}{r}{ball}`	$F_{x,\mathrm{grav}}\,r_{x,\mathrm{ball}} + F_{y,\mathrm{grav}}\,r_{y,\mathrm{ball}} + F_{z,\mathrm{grav}}\,r_{z,\mathrm{ball}}$

\vectsubdotsdvectsub{⟨*kernel1*⟩}{⟨*sub1*⟩}{⟨*kernel2*⟩}{⟨*sub2*⟩}
Dot of a subscripted vector and a subscripted vector's differential with symbolic components.

```
\vectsubdotsdvectsub{A}{ball}{B}{car}
```

$$\left\langle A_{x,\mathrm{ball}}, A_{y,\mathrm{ball}}, A_{z,\mathrm{ball}} \right\rangle \bullet \left\langle \mathrm{d}B_{x,\mathrm{car}}, \mathrm{d}B_{y,\mathrm{car}}, \mathrm{d}B_{z,\mathrm{car}} \right\rangle$$

\vectsubdotsDvectsub{⟨*kernel1*⟩}{⟨*sub1*⟩}{⟨*kernel2*⟩}{⟨*sub2*⟩}
Identical to \vectsubdotsdvectsub but uses Δ.

```
\vectsubdotsDvectsub{A}{ball}{B}{car}
```

$$\left\langle A_{x,\mathrm{ball}}, A_{y,\mathrm{ball}}, A_{z,\mathrm{ball}} \right\rangle \bullet \left\langle \Delta B_{x,\mathrm{car}}, \Delta B_{y,\mathrm{car}}, \Delta B_{z,\mathrm{car}} \right\rangle$$

\vectsubdotedvectsub{⟨*kernel1*⟩}{⟨*sub1*⟩}{⟨*kernel2*⟩}{⟨*sub2*⟩}
Dot of a subscripted vector and a subscripted vector's differential as an expanded sum.

```
\vectsubdotedvectsub{A}{ball}{B}{car}
```

$$A_{x,\mathrm{ball}}\,\mathrm{d}B_{x,\mathrm{car}} + A_{y,\mathrm{ball}}\,\mathrm{d}B_{y,\mathrm{car}} + A_{z,\mathrm{ball}}\,\mathrm{d}B_{z,\mathrm{car}}$$

\vectsubdoteDvectsub{⟨*kernel1*⟩}{⟨*sub1*⟩}{⟨*kernel2*⟩}{⟨*sub2*⟩}
Identical to \vectsubdotedvectsub but uses Δ.

```
\vectsubdoteDvectsub{A}{ball}{B}{car}
```

$$A_{x,\mathrm{ball}}\,\Delta B_{x,\mathrm{car}} + A_{y,\mathrm{ball}}\,\Delta B_{y,\mathrm{car}} + A_{z,\mathrm{ball}}\,\Delta B_{z,\mathrm{car}}$$

\vectsubdotsdvect{⟨*kernel1*⟩}{⟨*sub1*⟩}{⟨*kernel2*⟩}
Dot of a subscripted vector and a vector's differential with symbolic components.

```
\vectsubdotsdvect{A}{ball}{B}
```

$$\left\langle A_{x,\mathrm{ball}}, A_{y,\mathrm{ball}}, A_{z,\mathrm{ball}} \right\rangle \bullet \left\langle \mathrm{d}B_{x}, \mathrm{d}B_{y}, \mathrm{d}B_{z} \right\rangle$$

\vectsubdotsDvect{⟨*kernel1*⟩}{⟨*sub1*⟩}{⟨*kernel2*⟩}
Identical to \vectsubdotsdvect but uses Δ.

```
\vectsubdotsDvect{A}{ball}{B}
```

$$\left\langle A_{x,\mathrm{ball}}, A_{y,\mathrm{ball}}, A_{z,\mathrm{ball}} \right\rangle \bullet \left\langle \Delta B_{x}, \Delta B_{y}, \Delta B_{z} \right\rangle$$

\vectsubdotedvect{⟨*kernel1*⟩}{⟨*sub1*⟩}{⟨*kernel2*⟩}
Dot of a subscripted vector and a vector's differential as an expanded sum.

`\vectsubdotedvect{A}{ball}{B}`	$A_{x,\mathrm{ball}}\,\mathrm{d}x_B + A_{y,\mathrm{ball}}\,\mathrm{d}y_B + A_{z,\mathrm{ball}}\,\mathrm{d}z_B$

`\vectsubdoteDvect{`⟨*kernel1*⟩`}{`⟨*sub1*⟩`}{`⟨*kernel2*⟩`}`
Identical to `\vectsubdotedvect` but uses Δ.

`\vectsubdoteDvect{A}{ball}{B}`	$A_{x,\mathrm{ball}}\,\Delta x_B + A_{y,\mathrm{ball}}\,\Delta y_B + A_{z,\mathrm{ball}}\,\Delta z_B$

`\vectsubdotsdpos{`⟨*kernel*⟩`}{`⟨*sub*⟩`}`
Dot of a subscripted vector and a position vector's differential with symbolic components.

`\vectsubdotsdpos{A}{ball}`	$\left\langle A_{x,\mathrm{ball}}, A_{y,\mathrm{ball}}, A_{z,\mathrm{ball}} \right\rangle \bullet \langle \mathrm{d}x, \mathrm{d}y, \mathrm{d}z \rangle$

`\vectsubdotsDpos{`⟨*kernel*⟩`}{`⟨*sub*⟩`}`
Identical to `\vectsubdotsdpos` but uses Δ.

`\vectsubdotsDpos{A}{ball}`	$\left\langle A_{x,\mathrm{ball}}, A_{y,\mathrm{ball}}, A_{z,\mathrm{ball}} \right\rangle \bullet \langle \Delta x, \Delta y, \Delta z \rangle$

`\vectsubdotedpos{`⟨*kernel*⟩`}{`⟨*sub*⟩`}`
Dot of a subscripted vector and a position vector's differential as an expanded sum.

`\vectsubdotedpos{A}{ball}`	$A_{x,\mathrm{ball}}\,\mathrm{d}x + A_{y,\mathrm{ball}}\,\mathrm{d}y + A_{z,\mathrm{ball}}\,\mathrm{d}z$

`\vectsubdoteDpos{`⟨*kernel*⟩`}{`⟨*sub*⟩`}`
Identical to `\vectsubdotedpos` but uses Δ.

`\vectsubdoteDpos{A}{ball}`	$A_{x,\mathrm{ball}}\,\Delta x + A_{y,\mathrm{ball}}\,\Delta y + A_{z,\mathrm{ball}}\,\Delta z$

`\dervectdotsvect{`⟨*kernel1*⟩`}{`⟨*indvar*⟩`}{`⟨*kernel2*⟩`}`
Dot of a vector's derivative and a vector with symbolic components.

`\dervectdotsvect{A}{t}{B}`	$\left\langle \frac{\mathrm{d}A_x}{\mathrm{d}t}, \frac{\mathrm{d}A_y}{\mathrm{d}t}, \frac{\mathrm{d}A_z}{\mathrm{d}t} \right\rangle \bullet \left\langle B_x, B_y, B_z \right\rangle$

\Dervectdotsvect{⟨*kernel1*⟩}{⟨*indvar*⟩}{⟨*kernel2*⟩}
Identical to \dervectdotsvect but uses Δ.

```
\Dervectdotsvect{A}{t}{B}
```

$$\left\langle \frac{\Delta A_x}{\Delta t}, \frac{\Delta A_y}{\Delta t}, \frac{\Delta A_z}{\Delta t} \right\rangle \bullet \left\langle B_x, B_y, B_z \right\rangle$$

\dervectdotevect{⟨*kernel1*⟩}{⟨*indvar*⟩}{⟨*kernel2*⟩}
Dot of a vector's derivative and a vector as an expanded sum.

```
\dervectdotevect{A}{t}{B}
```

$$\frac{\mathrm{d}A_x}{\mathrm{d}t} x_B + \frac{\mathrm{d}A_y}{\mathrm{d}t} y_B + \frac{\mathrm{d}A_z}{\mathrm{d}t} z_B$$

\Dervectdotevect{⟨*kernel1*⟩}{⟨*indvar*⟩}{⟨*kernel2*⟩}
Identical to \dervectdotevect but uses Δ.

```
\Dervectdotevect{A}{t}{B}
```

$$\frac{\Delta A_x}{\Delta t} x_B + \frac{\Delta A_y}{\Delta t} y_B + \frac{\Delta A_z}{\Delta t} z_B$$

\vectdotsdervect{⟨*kernel1*⟩}{⟨*kernel2*⟩}{⟨*indvar*⟩}
Dot of a vector and a vector's derivative with symbolic components.

```
\vectdotsdervect{A}{B}{t}
```

$$\left\langle A_x, A_y, A_z \right\rangle \bullet \left\langle \frac{\mathrm{d}B_x}{\mathrm{d}t}, \frac{\mathrm{d}B_y}{\mathrm{d}t}, \frac{\mathrm{d}B_z}{\mathrm{d}t} \right\rangle$$

\vectdotsDervect{⟨*kernel1*⟩}{⟨*kernel2*⟩}{⟨*indvar*⟩}
Identical to \vectdotsdervect but uses Δ.

```
\vectdotsDervect{A}{B}{t}
```

$$\left\langle A_x, A_y, A_z \right\rangle \bullet \left\langle \frac{\Delta B_x}{\Delta t}, \frac{\Delta B_y}{\Delta t}, \frac{\Delta B_z}{\Delta t} \right\rangle$$

\vectdotedervect{⟨*kernel1*⟩}{⟨*kernel2*⟩}{⟨*indvar*⟩}
Dot of a vector and a vector's derivative as an expanded sum.

```
\vectdotedervect{A}{B}{t}
```

$$A_x \frac{\mathrm{d}B_x}{\mathrm{d}t} + A_y \frac{\mathrm{d}B_y}{\mathrm{d}t} + A_z \frac{\mathrm{d}B_z}{\mathrm{d}t}$$

\vectdoteDervect{⟨*kernel1*⟩}{⟨*kernel2*⟩}{⟨*indvar*⟩}
Identical to \vectdotedervect but uses Δ.

`\vectdoteDervect{A}{B}{t}`	$A_x \frac{\Delta B_x}{\Delta t} + A_y \frac{\Delta B_y}{\Delta t} + A_z \frac{\Delta B_z}{\Delta t}$

\dervectdotspos{⟨*kernel*⟩}{⟨*indvar*⟩}
Dot of a vector's derivative and a position vector with symbolic components.

`\dervectdotspos{A}{t}`	$\left\langle \frac{\mathrm{d}A_x}{\mathrm{d}t}, \frac{\mathrm{d}A_y}{\mathrm{d}t}, \frac{\mathrm{d}A_z}{\mathrm{d}t} \right\rangle \bullet \langle x, y, z \rangle$

\Dervectdotspos{⟨*kernel*⟩}{⟨*indvar*⟩}
Identical to \dervectdotspos but uses Δ.

`\Dervectdotspos{A}{t}`	$\left\langle \frac{\Delta A_x}{\Delta t}, \frac{\Delta A_y}{\Delta t}, \frac{\Delta A_z}{\Delta t} \right\rangle \bullet \langle x, y, z \rangle$

\dervectdotepos{⟨*kernel*⟩}{⟨*indvar*⟩}
Dot of a vector's derivative and a position vector as an expanded sum.

`\dervectdotepos{A}{t}`	$\frac{\mathrm{d}A_x}{\mathrm{d}t} x + \frac{\mathrm{d}A_y}{\mathrm{d}t} y + \frac{\mathrm{d}A_z}{\mathrm{d}t} z$

\Dervectdotepos{⟨*kernel*⟩}{⟨*indvar*⟩}
Identical to \dervectdotepos but uses Δ.

`\Dervectdotepos{A}{t}`	$\frac{\Delta A_x}{\Delta t} x + \frac{\Delta A_y}{\Delta t} y + \frac{\Delta A_z}{\Delta t} z$

\dervectdotsdvect{⟨*kernel1*⟩}{⟨*indvar*⟩}{⟨*kernel2*⟩}
Dot of a vector's derivative and a vector's differential with symbolic components.

`\dervectdotsdvect{A}{t}{B}`	$\left\langle \frac{\mathrm{d}A_x}{\mathrm{d}t}, \frac{\mathrm{d}A_y}{\mathrm{d}t}, \frac{\mathrm{d}A_z}{\mathrm{d}t} \right\rangle \bullet \left\langle \mathrm{d}B_x, \mathrm{d}B_y, \mathrm{d}B_z \right\rangle$

\DervectdotsDvect{⟨*kernel1*⟩}{⟨*indvar*⟩}{⟨*kernel2*⟩}
Identical to \dervectdotsdvect but uses Δ.

```
\DervectdotsDvect{A}{t}{B}
```

$$\left\langle \frac{\Delta A_x}{\Delta t}, \frac{\Delta A_y}{\Delta t}, \frac{\Delta A_z}{\Delta t} \right\rangle \bullet \left\langle \Delta B_x, \Delta B_y, \Delta B_z \right\rangle$$

\dervectdotedvect{⟨*kernel1*⟩}{⟨*indvar*⟩}{⟨*kernel2*⟩}
Dot of a vector's derivative and a vector's differential as an expanded sum.

```
\dervectdotedvect{A}{t}{B}
```

$$\frac{\mathrm{d}A_x}{\mathrm{d}t}\mathrm{d}B_x + \frac{\mathrm{d}A_y}{\mathrm{d}t}\mathrm{d}B_y + \frac{\mathrm{d}A_z}{\mathrm{d}t}\mathrm{d}B_z$$

\DervectdoteDvect{⟨*kernel1*⟩}{⟨*indvar*⟩}{⟨*kernel2*⟩}
Identical to \dervectdotedvect but uses Δ.

```
\DervectdoteDvect{A}{t}{B}
```

$$\frac{\Delta A_x}{\Delta t}\Delta B_x + \frac{\Delta A_y}{\Delta t}\Delta B_y + \frac{\Delta A_z}{\Delta t}\Delta B_z$$

\dervectdotsdpos{⟨*kernel*⟩}{⟨*indvar*⟩}
Dot of a vector's derivative and a position vector's differential with symbolic components.

```
\dervectdotsdpos{A}{t}
```

$$\left\langle \frac{\mathrm{d}A_x}{\mathrm{d}t}, \frac{\mathrm{d}A_y}{\mathrm{d}t}, \frac{\mathrm{d}A_z}{\mathrm{d}t} \right\rangle \bullet \langle \mathrm{d}x, \mathrm{d}y, \mathrm{d}z \rangle$$

\DervectdotsDpos{⟨*kernel*⟩}{⟨*indvar*⟩}
Identical to \dervectdotsdpos but uses Δ.

```
\DervectdotsDpos{A}{t}
```

$$\left\langle \frac{\Delta A_x}{\Delta t}, \frac{\Delta A_y}{\Delta t}, \frac{\Delta A_z}{\Delta t} \right\rangle \bullet \langle \Delta x, \Delta y, \Delta z \rangle$$

\dervectdotedpos{⟨*kernel*⟩}{⟨*indvar*⟩}
Dot of a vector's derivative and a position vector's differential as an expanded sum.

```
\dervectdotedpos{A}{t}
```

$$\frac{\mathrm{d}A_x}{\mathrm{d}t}\mathrm{d}x + \frac{\mathrm{d}A_y}{\mathrm{d}t}\mathrm{d}y + \frac{\mathrm{d}A_z}{\mathrm{d}t}\mathrm{d}z$$

\DervectdoteDpos{⟨*kernel*⟩}{⟨*indvar*⟩}
Identical to \dervectdotedpos but uses Δ.

`\DervectdoteDpos{A}{t}`	$\frac{\Delta A_x}{\Delta t}\Delta x + \frac{\Delta A_y}{\Delta t}\Delta y + \frac{\Delta A_z}{\Delta t}\Delta z$

5.7.8 Expressions Containing Crosses

All of the naming conventions documented in earlier commands still apply.

\vectcrossvect{⟨*kernel1*⟩}{⟨*kernel2*⟩}
Cross of two vectors.

`\vectcrossvect{\vect{r}}{\vect{p}}`	$\vec{r} \times \vec{p}$

\ltriplecross{⟨*kernel1*⟩}{⟨*kernel2*⟩}{⟨*kernel3*⟩}
Symbol for left associated triple cross product.

`\ltriplecross{\vect{A}}{\vect{B}}{\vect{C}}`	$\left(\vec{A} \times \vec{B}\right) \times \vec{C}$

\rtriplecross{⟨*kernel1*⟩}{⟨*kernel2*⟩}{⟨*kernel3*⟩}
Symbol for right associated triple cross product.

`\rtriplecross{\vect{A}}{\vect{B}}{\vect{C}}`	$\vec{A} \times \left(\vec{B} \times \vec{C}\right)$

\ltriplescalar{⟨*kernel1*⟩}{⟨*kernel2*⟩}{⟨*kernel3*⟩}
Symbol for left associated triple scalar product.

`\ltriplescalar{\vect{A}}{\vect{B}}{\vect{C}}`	$\vec{A} \times \vec{B} \bullet \vec{C}$

\rtriplescalar{⟨*kernel1*⟩}{⟨*kernel2*⟩}{⟨*kernel3*⟩}
Symbol for right associated triple scalar product.

`\rtriplescalar{\vect{A}}{\vect{B}}{\vect{C}}`	$\vec{A} \bullet \vec{B} \times \vec{C}$

5.7.9 Basis Vectors and Bivectors

If you use geometric algebra or tensors, eventually you will need symbols for basis vectors and basis bivectors.

\ezero
Symbols for basis vectors with lower indices up to 4.

```
\ezero \eone \etwo \ethree \efour
```

$\mathbf{e}_0\ \mathbf{e}_1\ \mathbf{e}_2\ \mathbf{e}_3\ \mathbf{e}_4$

\uezero
Symbols for normalized basis vectors with lower indices up to 4.

```
\uezero \ueone \uetwo \uethree \uefour
```

$\hat{\mathbf{e}}_0\ \hat{\mathbf{e}}_1\ \hat{\mathbf{e}}_2\ \hat{\mathbf{e}}_3\ \hat{\mathbf{e}}_4$

\ezerozero
Symbols for basis bivectors with lower indices up to 4.

```
\ezerozero \ezeroone \ezerotwo \ezerothree ↩
      ↪\ezerofour up to \efourfour
```

$\mathbf{e}_{00}\ \mathbf{e}_{01}\ \mathbf{e}_{02}\ \mathbf{e}_{03}\ \mathbf{e}_{04}$ up to $\mathbf{e}_{44}$

\euzero
Symbols for basis vectors with upper indices up to 4.

```
\euzero \euone \eutwo \euthree \eufour
```

$\mathbf{e}^0\ \mathbf{e}^1\ \mathbf{e}^2\ \mathbf{e}^3\ \mathbf{e}^4$

\euzerozero
Symbols for basis bivectors with upper indices up to 4.

```
\euzerozero \euzeroone \euzerotwo \euzerothree ↩
      ↪\euzerofour up to \eufourfour
```

$\mathbf{e}^{00}\ \mathbf{e}^{01}\ \mathbf{e}^{02}\ \mathbf{e}^{03}\ \mathbf{e}^{04}$ up to $\mathbf{e}^{44}$

\gzero
Symbols for basis vectors, with γ as the kernel, with lower indices up to 4.

```
\gzero \gone \gtwo \gthree \gfour
```

$\gamma_0\ \gamma_1\ \gamma_2\ \gamma_3\ \gamma_4$

\guzero
Symbols for basis vectors, with γ as the kernel, with upper indices up to 4.

```
\guzero \guone \gutwo \guthree \gufour
```

$\gamma^0\ \gamma^1\ \gamma^2\ \gamma^3\ \gamma^4$

\gzerozero
Symbols for basis bivectors, with γ as the kernel, with lower indices up to 4.

```
\gzerozero \gzeroone \gzerotwo \gzerothree ↵
      ↪\gzerofour up to \gfourfour
```

$\gamma_{00}\ \gamma_{01}\ \gamma_{02}\ \gamma_{03}\ \gamma_{04}$ up to γ_{44}

\guzerozero
Symbols for basis bivectors, with γ as the kernel, with upper indices up to 4.

```
\guzerozero \guzeroone \guzerotwo \guzerothree ↵
      ↪\guzerofour up to \gufourfour
```

$\gamma^{00}\ \gamma^{01}\ \gamma^{02}\ \gamma^{03}\ \gamma^{04}$ up to γ^{44}

\colvector{⟨*commadelimitedlistofcomps*⟩}
Typesets column vectors.

```
\colvector{\msup{x}{0},\msup{x}{1},\msup{x}{2},
\msup{x}{3}}
```

$$\begin{pmatrix} x^0 \\ x^1 \\ x^2 \\ x^3 \end{pmatrix}$$

\rowvector{⟨*commadelimitedlistofcomps*⟩}
Typesets row vectors.

```
\rowvector{\msup{x}{0},\msup{x}{1},\msup{x}{2},
\msup{x}{3}}
```

$$\begin{pmatrix} x^0 & x^1 & x^2 & x^3 \end{pmatrix}$$

\scompscvect[⟨*anynonzero*⟩]{⟨*kernel*⟩}
Typesets symbolic components of column 3- or 4-vectors (use any nonzero value for the optional argument to typeset a 4-vector).

Allow for superscripts.

```
\begin{align*}
\vect{p} &= \scompscvect{p} \\
\vect{p} &= \scompscvect[4]{p}
\end{align*}
```

$$\vec{p} = \begin{pmatrix} p_1 \\ p_2 \\ p_3 \end{pmatrix}$$
$$\vec{p} = \begin{pmatrix} p_0 \\ p_1 \\ p_2 \\ p_3 \end{pmatrix}$$

Allow for superscripts.

\scompsrvect[⟨*anynonzero*⟩]{⟨*kernel*⟩}

Typesets symbolic components of row 3- or 4-vectors (use any nonzero value for the optional argument to typeset a 4-vector).

```
\begin{align*}
\vect{p} &= \scompsrvect{p} \\
\vect{p} &= \scompsrvect[4]{p}
\end{align*}
```

$$\vec{p} = \begin{pmatrix} p_1 & p_2 & p_3 \end{pmatrix}$$
$$\vec{p} = \begin{pmatrix} p_0 & p_1 & p_2 & p_3 \end{pmatrix}$$

5.8 Physical Constants

5.8.1 Defining Physical Constants

\newphysicsconstant{⟨*newname*⟩}{⟨*symbol*⟩}{⟨*value*⟩}{⟨*baseunits*⟩}[⟨*drvdunits*⟩][⟨*tradunits*⟩]

Defines a new physical constant.

```
Here is how \oofpez (the Coulomb constant) is defined internally.
\newphysicsconstant{oofpez}
{\ensuremath{\frac{1}{\phantom{_o}4\pi\ssub{\epsilon}{o}}}}
{\scin[9]{9}}
{\ensuremath{\m\cubed\usk\kg\usk\s^{-4}\usk\A\rpsquared}}
[\m\per\farad]
[\newton\usk\m\squared\per\coulomb\squared]
```

Using this command causes several things to happen.

- A command **\newname** is created and contains the constant and units typeset according to the options given when **mandi** was loaded.
- A command **\newnamemathsymbol** is created that expresses **only** the constant's mathematical symbol.
- A command **\newnamevalue** is created that expresses **only** the constant's numerical value.
- A command **\newnamebaseunit** is created that expresses the constant and its units in *baseunits* form.
- A command **\newnamedrvdunit** is created that expresses the constant and its units in *drvdunits* form.

- A command **\newnametradunit** is created that expresses the constant and its units in *tradunits* form.
- A command **\newnameonlybaseunit** is created that expresses **only** the constant's units in *baseunits* form.
- A command **\newnameonlydrvdunit** is created that expresses **only** the constant's units in *drvdunits* form.
- A command **\newnameonlytradunit** is created that expresses **only** the constant's units in *tradunits* form.

None of these commands takes any arguments.

5.8.2 Predefined Physical Constants

\oofpez
Coulomb constant.

`\(\oofpezmathsymbol \approx \oofpez\)`	$\frac{1}{4\pi\epsilon_{\mathrm{o}}} \approx 8.9876 \times 10^{9}\,\mathrm{N \cdot m^2/C^2}$

\oofpezcs
Alternate form of Coulomb constant.

`\(\oofpezcsmathsymbol \approx \oofpezcs\)`	$\frac{1}{4\pi\epsilon_{\mathrm{o}} c^2} \approx 10^{-7}\,\mathrm{N \cdot s^2/C^2}$

\vacuumpermittivity
Vacuum permittivity.

`\(\vacuumpermittivitymathsymbol \approx ↩ ↪\vacuumpermittivity\)`	$\epsilon_{\mathrm{o}} \approx 8.8542 \times 10^{-12}\,\mathrm{C^2/N \cdot m^2}$

\mzofp
Biot-Savart constant.

`\(\mzofpmathsymbol \approx \mzofp\)`	$\frac{\mu_{\mathrm{o}}}{4\pi} \approx 10^{-7}\,\mathrm{T \cdot m/A}$

\vacuumpermeability
Vacuum permeability.

`\(\vacuumpermeabilitymathsymbol \approx ↩ ↪\vacuumpermeability\)`	$\mu_{\mathrm{o}} \approx 4\pi \times 10^{-7}\,\mathrm{T \cdot m/A}$

\boltzmann
Boltzmann constant.

```
\(\boltzmannmathsymbol \approx \boltzmann\)
```

$k_{\mathrm{B}} \approx 1.3806 \times 10^{-23}\,\mathrm{J/K}$

\boltzmanninev
Alternate form of Boltlzmann constant.

```
\(\boltzmanninevmathsymbol \approx ❩
      ❵\boltzmanninev\)
```

$k_{\mathrm{B}} \approx 8.6173 \times 10^{-5}\,\mathrm{eV/K}$

\stefan
Stefan-Boltzmann constant.

```
\(\stefanboltzmannmathsymbol \approx ❩
      ❵\stefanboltzmann\)
```

$\sigma \approx 5.6704 \times 10^{-8}\,\mathrm{W/m^2 \cdot K^4}$

\planck
Planck constant.

```
\(\planckmathsymbol \approx \planck\)
```

$h \approx 6.6261 \times 10^{-34}\,\mathrm{J \cdot s}$

\planckinev
Alternate form of Planck constant.

```
\(\planckmathsymbol \approx \planckinev\)
```

$h \approx 4.1357 \times 10^{-15}\,\mathrm{eV \cdot s}$

\planckbar
Reduced Planck constant (Dirac constant).

```
\(\planckbarmathsymbol \approx \planckbar\)
```

$\hbar \approx 1.0546 \times 10^{-34}\,\mathrm{J \cdot s}$

\planckbarinev
Alternate form of reduced Planck constant (Dirac constant).

```
\(\planckbarmathsymbol \approx \planckbarinev\)
```

$\hbar \approx 6.5821 \times 10^{-16}\,\mathrm{eV \cdot s}$

\planckc
Planck constant times light speed.

```
\(\planckcmathsymbol \approx \planckc\)
```

$hc \approx 1.9864 \times 10^{-25}\,\mathrm{J \cdot m}$

\planckcinev
Alternate form of Planck constant times light speed.

```
\(\planckcinevmathsymbol \approx \planckcinev\)
```

$hc \approx 1.9864 \times 10^{-25}\,\mathrm{eV \cdot nm}$

\rydberg
Rydberg constant.

```
\(\rydbergmathsymbol \approx \rydberg\)
```

$R_{\infty} \approx 1.0974 \times 10^{7}\,\mathrm{m^{-1}}$

\bohrradius
Bohr radius.

```
\(\bohrradiusmathsymbol \approx \bohrradius\)
```

$a_{0} \approx 5.2918 \times 10^{-11}\,\mathrm{m}$

\finestructure
Fine structure constant.

```
\(\finestructuremathsymbol \approx ❩
      ❨\finestructure\)
```

$\alpha \approx 7.2974 \times 10^{-3}$

\avogadro
Avogadro constant.

```
\(\avogadromathsymbol \approx \avogadro\)
```

$N_{\mathrm{A}} \approx 6.0221 \times 10^{23}\,\mathrm{mol^{-1}}$

\universalgrav
Universal gravitational constant.

`\(\universalgravmathsymbol \approx ❩ ❨\universalgrav\)`	$G \approx 6.6738 \times 10^{-11}\,\mathrm{N \cdot m^2/kg^2}$

\surfacegravfield
Earth's surface gravitational field strength.

`\(\surfacegravfieldmathsymbol \approx ❩ ❨\surfacegravfield\)`	$g \approx 9.80\,\mathrm{m/s^2}$

\clight
Magnitude of light's velocity (photon constant).

`\(\clightmathsymbol \approx \clight\)`	$c \approx 2.9979 \times 10^{8}\,\mathrm{m/s}$

\clightinfeet
Alternate of magnitude of light's velocity (photon constant).

`\(\clightinfeetmathsymbol \approx \clightinfeet\)`	$c \approx 0.9836\,\mathrm{ft/ns}$

\Ratom
Approximate atomic radius.

`\(\Ratommathsymbol \approx \Ratom\)`	$r_{\mathrm{atom}} \approx 10^{-10}\,\mathrm{m}$

\Mproton
Proton mass.

`\(\Mprotonmathsymbol \approx \Mproton\)`	$m_{\mathrm{proton}} \approx 1.6726 \times 10^{-27}\,\mathrm{kg}$

\Mneutron
Neutron mass.

`\(\Mneutronmathsymbol \approx \Mneutron\)`	$m_{\text{neutron}} \approx 1.6749 \times 10^{-27}\,\text{kg}$

\Mhydrogen
Hydrogen atom mass.

`\(\Mhydrogenmathsymbol \approx \Mhydrogen\)`	$m_{\text{hydrogen}} \approx 1.6737 \times 10^{-27}\,\text{kg}$

\Melectron
Electron mass.

`\(\Melectronmathsymbol \approx \Melectron\)`	$m_{\text{electron}} \approx 9.1094 \times 10^{-31}\,\text{kg}$

\echarge
Elementary charge quantum.

`\(\echargemathsymbol \approx \echarge\)`	$e \approx 1.6022 \times 10^{-19}\,\text{C}$

\Qelectron
Electron charge.

`\(\Qelectronmathsymbol \approx \Qelectron\)`	$Q_{\text{electron}} \approx -1.6022 \times 10^{-19}\,\text{C}$

\qelectron
Alias for `\Qelectron`.

\Qproton
Proton charge.

`\(\Qprotonmathsymbol \approx \Qproton\)`	$Q_{\text{proton}} \approx +1.6022 \times 10^{-19}\,\text{C}$

\qproton
Alias for `\Qproton`.

\MEarth
Earth's mass.

`\(\MEarthmathsymbol \approx \MEarth\)`	$M_{\text{Earth}} \approx 5.9736 \times 10^{24}\,\text{kg}$

\MMoon
Moon's mass.

`\(\MMoonmathsymbol \approx \MMoon\)`	$M_{\text{Moon}} \approx 7.3459 \times 10^{22}\,\text{kg}$

\MSun
Sun's mass.

`\(\MSunmathsymbol \approx \MSun\)`	$M_{\text{Sun}} \approx 1.9891 \times 10^{30}\,\text{kg}$

\REarth
Earth's radius.

`\(\REarthmathsymbol \approx \REarth\)`	$R_{\text{Earth}} \approx 6.3675 \times 10^{6}\,\text{m}$

\RMoon
Moon's radius.

`\(\RMoonmathsymbol \approx \RMoon\)`	$R_{\text{Moon}} \approx 1.7375 \times 10^{6}\,\text{m}$

\RSun
Sun's radius.

`\(\RSunmathsymbol \approx \RSun\)`	$R_{\text{Sun}} \approx 6.9634 \times 10^{8}\,\text{m}$

\ESdist
Earth-Sun distance.

`\(\ESdistmathsymbol \approx \SEdist\)`	$\left\vert \vec{r}_{\mathrm{ES}} \right\vert \approx 1.4960 \times 10^{11}\,\mathrm{m}$

\SEdist
Alias for \ESdist.

\EMdist
Earth-Moon distance.

`\(\EMdistmathsymbol \approx \EMdist\)`	$\left\vert \vec{r}_{\mathrm{EM}} \right\vert \approx 3.8440 \times 10^{8}\,\mathrm{m}$

\MEdist
Alias for \EMdist.

5.9 Astronomical Constants and Quantities

\LSun
Sun's luminosity.

`\(\LSunmathsymbol \approx \LSun\)`	$L_{\mathrm{Sun}} \approx 3.8460 \times 10^{26}\,\mathrm{J/s}$

\TSun
Sun's effective temperature.

`\(\TSunmathsymbol \approx \TSun\)`	$T_{\mathrm{Sun}} \approx 5778\,\mathrm{K}$

\MagSun
Sun's absolute magnitude.

`\(\MagSunmathsymbol \approx \MagSun\)`	$M_{\mathrm{Sun}} \approx +4.83$

\magSun
Sun's apparent magnitude.

`\(\magSunmathsymbol \approx \magSun\)`	$m_{\mathrm{Sun}} \approx -26.74$

\Lstar[⟨*object*⟩]
Symbol for stellar luminosity.

`\Lstar \Lstar[Sirius]`	$L_\star$ L_{Sirius}

\Lsolar
Symbol for solar luminosity as a unit. Really just an alias for `\Lstar[\(\odot\)]`.

`\Lsolar`	$L_\odot$

\Tstar[⟨*object*⟩]
Symbol for stellar temperature.

`\Tstar \Tstar[Sirius]`	$T_\star$ T_{Sirius}

\Tsolar
Symbol for solar temperature as a unit. Really just an alias for `\Tstar[\(\odot\)]`.

`\Tsolar`	$T_\odot$

\Rstar[⟨*object*⟩]
Symbol for stellar radius.

`\Rstar \Rstar[Sirius]`	$R_\star$ R_{Sirius}

\Rsolar
Symbol for solar radius as a unit. Really just an alias for `\Rstar[\(\odot\)]`.

`\Rsolar`	$R_\odot$

\Mstar[⟨*object*⟩]
Symbol for stellar mass.

```
\Mstar \Mstar[Sirius]
```
$M_\star\, M_{\mathrm{Sirius}}$

\Msolar
Symbol for solar mass as a unit. Really just an alias for `\Mstar[\(\odot\)]`.

```
\Msolar
```
$M_\odot$

\Fstar[⟨*object*⟩]
Symbol for stellar flux.

```
\Fstar \Fstar[Sirius]
```
$F_\star\, F_{\mathrm{Sirius}}$

\Fsolar
Symbol for solar flux as a unit. Really just an alias for `\Fstar[\(\odot\)]`.

```
\Fsolar
```
$F_\odot$

\fstar
Alias for `\Fstar`.

\fsolar
Alias for `\fsolar`.

\Magstar[⟨*object*⟩]
Symbol for stellar absolute magnitude.

```
\Magstar \Magstar[Sirius]
```
$M_\star\, M_{\mathrm{Sirius}}$

\Magsolar
Symbol for solar absolute magnitude as a unit. Really just an alias for `\Magstar[\(\odot\)]`.

```
\Magsolar
```
$M_\odot$

\magstar[⟨*object*⟩]
Symbol for stellar apparent magnitude.

```
\magstar \magstar[Sirius]
```
$m_\star\, m_{\text{Sirius}}$

\magsolar
Symbol for solar apparent magnitude as a unit. Really just an alias for `\magstar[\(\odot\)]`.

```
\magsolar
```
$m_\odot$

\Dstar[⟨*object*⟩]
Symbol for stellar distance.

```
\Dstar \Dstar[Sirius]
```
$D_\star\, D_{\text{Sirius}}$

\Dsolar
Symbol for solar distance as a unit. Really just an alias for `\Dstar[\(\odot\)]`.

```
\Dsolar
```
$D_\odot$

\dstar
Alias for `\Dstar` that uses a lower case d.

\dsolar
Alias for `\Dsolar` that uses a lower case d.

5.10 Frequently Used Fractions

\onehalf
Small fractions with numerator 1 and denominators up to 10.

```
\(\onehalf \cdots \onetenth\)
```
$\frac{1}{2} \cdots \frac{1}{10}$

\twooneths
Small fractions with numerator 2 and denominators up to 10.

```
\(\twooneths \cdots \twotenths\)
```
$\frac{2}{1} \cdots \frac{2}{10}$

\threeoneths
Small fractions with numerator 3 and denominators up to 10.

`\(\threeoneths \cdots \threetenths\)`	$\frac{3}{1} \cdots \frac{3}{10}$

\fouroneths{⟨*magnitude*⟩}
Small fractions with numerator 4 and denominators up to 10.

`\(\fouroneths \cdots \fourtenths\)`	$\frac{4}{1} \cdots \frac{4}{10}$

5.11 Calculus

\dx{⟨*variable*⟩}
Properly typesets variables of integration (the d should not be in italics and should be properly spaced relative to the integrand).

`\( \dx{y} \)`	$\mathrm{d}y$

\evalfromto{⟨*antiderivative*⟩}{⟨*lower*⟩}{⟨*upper*⟩}
Properly typesets the evaluation of definite integrals.

`\( \evalfromto{\onethird y^3}{0}{3} \)`	$\frac{1}{3}y^3\Big\vert_0^3$

\evalat{⟨*expression*⟩}{⟨*evaluationpoint*⟩}
Properly typesets quantities evaluated at a particular point or value.

Combine with \evaluatedat?

`\( \evalat{\dbydt[x]}{t=1} \)`	$\frac{\mathrm{d}x}{\mathrm{d}t}\Big\vert_{t=1}$

\evaluatedat{⟨*evaluationpoint*⟩}
Properly indicates evaluation at a particular point or value without specifying the quantity.

```
\( \mbox{LMST}\evaluatedat{\longitude{0}} \)
```

$\mbox{LMST}\evaluatedat{\longitude{0}}$

\integral[⟨*lower*⟩][⟨*upper*⟩]{⟨*integrand*⟩}{⟨*var*⟩}
Typesets indefinite and definite integrals.

```
\[ \integral{y^2}{y} \]
\[ \integral[0][3]{y^2}{y} \]
```

$$\integral{y^2}{y}$$
$$\integral[0][3]{y^2}{y}$$

\Integral[⟨*lower*⟩][⟨*upper*⟩]{⟨*integrand*⟩}{⟨*var*⟩}
Typesets indefinite and definite integrals.

```
\[ \Integral{y^2}{y} \]
\[ \Integral[0][3]{y^2}{y} \]
```

$$\Integral{y^2}{y}$$
$$\Integral[0][3]{y^2}{y}$$

\opensurfintegral{⟨*surfacename*⟩}{⟨*vectorname*⟩}
Integral over an open surface of the normal component of a vector field.

```
\[ \opensurfintegral{S}{E} \]
```

$$\opensurfintegral{S}{E}$$

\opensurfIntegral{⟨*surfacename*⟩}{⟨*vectorname*⟩}
Integral over an open surface of the normal component of a vector field.

```
\[ \opensurfIntegral{S}{E} \]
```

$$\opensurfIntegral{S}{E}$$

`\closedsurfintegral`{⟨*surfacename*⟩}{⟨*vectorname*⟩}
Integral over a closed surface of the normal component of a vector field.

```
\[ \closedsurfintegral{S}{E} \]
```

$$\oint_S \vec{E} \bullet \widehat{n} \, \mathrm{d}A$$

`\closedsurfIntegral`{⟨*surfacename*⟩}{⟨*vectorname*⟩}
Integral over a closed surface of the normal component of a vector field.

```
\[ \closedsurfIntegral{S}{E} \]
```

$$\Large\oint_{\mathbf{S}} \normalsize\vec{E} \bullet \widehat{n} \, \mathrm{d}A$$

`\openlineintegral`{⟨*pathname*⟩}{⟨*vectorname*⟩}
Integral over an open path of the tangential component of a vector field.

```
\[ \openlineintegral{C}{E} \]
```

$$\int_C \vec{E} \bullet \widehat{t} \, \mathrm{d}\ell$$

`\openlineIntegral`{⟨*pathname*⟩}{⟨*vectorname*⟩}
Integral over an open path of the tangential component of a vector field.

```
\[ \openlineIntegral{C}{E} \]
```

$$\Large\int_{\mathbf{C}} \normalsize\vec{E} \bullet \widehat{t} \, \mathrm{d}\ell$$

`\closedlineintegral`{⟨*pathname*⟩}{⟨*vectorname*⟩}
Integral over a closed path of the tangential component of a vector field.

```
\[ \closedlineintegral{C}{E} \]
```

$$\oint_C \vec{E} \bullet \widehat{t} \, \mathrm{d}\ell$$

`\closedlineIntegral`{⟨*pathname*⟩}{⟨*vectorname*⟩}
Integral over a closed path of the tangential component of a vector field.

```
\[ \closedlineIntegral{C}{E} \]
```

$$\oint_{\mathbf{C}} \vec{E} \bullet \hat{t}\,\mathrm{d}\ell$$

For line integrals, I have not employed the common $\mathrm{d}\vec{\ell}$ symbol. Instead, I use $\hat{t}\,\mathrm{d}\ell$ for two main reason. The first is that line integrals require the component of a vector that is tangent to a curve, and I use $\hat{t}$ to denote a unit tangent. The second is that the new notation looks more like that for surface integrals.

`\dbydt`[⟨*operand*⟩]
First time derivative operator. Use `\DbyDt` to get Δ instead of d.

```
\( \dbydt \) or \( \dbydt x \) or \dbydt[x]
```

$$\frac{\mathrm{d}}{\mathrm{d}t} \text{ or } \frac{\mathrm{d}}{\mathrm{d}t}x \text{ or } \frac{\mathrm{d}x}{\mathrm{d}t}$$

`\ddbydt`[⟨*operand*⟩]
Second time derivative operator. Use `\DDbyDt` to get Δ instead of d.

```
\( \ddbydt \) or \( \ddbydt x \) or \ddbydt[x]
```

$$\frac{\mathrm{d}^2}{\mathrm{d}t^2} \text{ or } \frac{\mathrm{d}^2}{\mathrm{d}t^2}x \text{ or } \frac{\mathrm{d}^2x}{\mathrm{d}t^2}$$

`\pbypt`[⟨*operand*⟩]
First partial time derivative operator.

```
\( \pbypt \) or \( \pbypt x \) or \pbypt[x]
```

$$\frac{\partial}{\partial t} \text{ or } \frac{\partial}{\partial t}x \text{ or } \frac{\partial x}{\partial t}$$

`\ppbypt`[⟨*operand*⟩]
Second partial time derivative operator.

```
\( \ppbypt \) or \( \ppbypt x \) or \ppbypt[x]
```

$$\frac{\partial^2}{\partial t^2} \text{ or } \frac{\partial^2}{\partial t^2}x \text{ or } \frac{\partial^2 x}{\partial t^2}$$

`\dbyd{`⟨*dependentvariable*⟩`}{`⟨*indvar*⟩`}`
Generic first derivative operator. Use `\DbyD` to get Δ instead of d.

```
\( \dbyd{f}{y} \)
```

$$\frac{\mathrm{d}f}{\mathrm{d}y}$$

\ddbyd{⟨*dependentvariable*⟩}{⟨*indvar*⟩}
Generic second derivative operator. Use \DDbyD to get Δ instead of d.

```
\( \ddbyd{f}{y} \)
```

$$\frac{\mathrm{d}^2 f}{\mathrm{d}y^2}$$

\pbyp{⟨*dependentvariable*⟩}{⟨*indvar*⟩}
Generic first partial derivative operator.

```
\( \pbyp{f}{y} \)
```

$$\frac{\partial f}{\partial y}$$

\ppbyp{⟨*dependentvariable*⟩}{⟨*indvar*⟩}
Generic second partial derivative operator.

```
\( \ppbyp{f}{y} \)
```

$$\frac{\partial^2 f}{\partial y^2}$$

\gradient
Gradient operator.

```
\gradient
```

$$\nabla$$

\divergence
Divergente operator.

```
\divergence
```

$$\nabla\bullet$$

\curl
Curl operator.

```
\curl
```

$$\nabla\times$$

\laplacian
Laplacian operator.

`\laplacian`	∇^2

`\dalembertian`
D'Alembertian operator.

`\dalembertian`	$\Box$

`\seriesfofx`
Series expansion of $f\left(x\right)$ around $x = a$.

`\seriesfofx`

$$f\left(x\right) \approx f\left(a\right) + \frac{f'\left(a\right)}{1!}\left(x-a\right) + \frac{f''\left(a\right)}{2!}\left(x-a\right)^2 + \frac{f'''\left(a\right)}{3!}\left(x-a\right)^3 + \ldots$$

`\seriesexpx`
Series expansion of e^{x}.

`\seriesexpx`	$e^x \approx 1 + x + \frac{x^2}{2!} + \frac{x^3}{3!} + \ldots$

`\seriessinx`
Series expansion of $\sin x$.

`\seriessinx`	$\sin x \approx x - \frac{x^3}{3!} + \frac{x^5}{5!} - \ldots$

`\seriescosx`
Series expansion of $\cos x$.

`\seriescosx`	$\cos x \approx 1 - \frac{x^2}{2!} + \frac{x^4}{4!} - \ldots$

`\seriestanx`
Series expansion of $\tan x$.

`\seriestanx`	$\tan x \approx x + \frac{x^3}{3} + \frac{2x^5}{15} + \ldots$

`\seriesatox`
Series expansion of a^x.

`\seriesatox`	$a^x \approx 1 + x \ln a + \frac{(x \ln a)^2}{2!} + \frac{(x \ln a)^3}{3!} + \ldots$

`\serieslnoneplusx`
Series expansion of $\ln(1+x)$.

`\serieslnoneplusx`	$\ln(1 \pm x) \approx \pm x - \frac{x^2}{2} \pm \frac{x^3}{3} - \frac{x^4}{4} \pm \ldots$

`\binomialseries`
Series expansion of $(1+x)^n$.

`\binomialseries`	$(1+x)^n \approx 1 + nx + \frac{n(n-1)}{2!}x^2 + \ldots$

`\diracdelta{`⟨*arg*⟩`}`
Dirac delta function.

`\diracdelta{x}`	$\boldsymbol{\delta}(x)$

5.12 Other Useful Commands

`\asin`
Symbol for inverse sine and other inverse circular trig functions.

`\( \asin \acos \atan \asec \acsc \acot \)`	$\sin^{-1}\ \cos^{-1}\ \tan^{-1}\ \sec^{-1}\ \csc^{-1}\ \cot^{-1}$

`\sech`
Hyperbolic and inverse hyperbolic functions not defined in LaTeX.

```
\( \sech \csch \asinh \acosh \atanh \asech
   \acsch \acoth \)
```

$\sech \csch \asinh \acosh \atanh \asech \acsch \acoth$

\sgn{⟨*arg*⟩}
Signum function.

```
\( \sgn \)
```

$\sgn$

\dex
Decimal exponentiation function (used in astrophysics).

```
\( \dex \)
```

$\dex$

\logb[⟨*base*⟩]
Logarithm to an arbitrary base.

```
\logb 8 \logb[2] 8
```

$\logb 8 \logb[2] 8$

\cB
Alternate symbol for magnetic field inspired by Tom Moore.

```
\cB \vect{\cB}
```

$\cB \vect{\cB}$

\newpi
Bob Palais' symbol for 2π.

```
\newpi
```

$\newpi$

\scripty{⟨*kernel*⟩}
Command to get fonts in Griffith's electrodynamics textbook.

```
\scripty{r}
```

$\scripty{r}$

\flux[⟨*label*⟩]
Symbol for flux of a vector field.

```
\flux \flux[E]
```
$\Phi\ \Phi_{\mathrm{E}}$

\abs{⟨*arg*⟩}
Absolute value function.

```
\abs{-4}
```
$|-4|$

\magof{⟨*arg*⟩}
Magnitude of a quantity (lets you selectively use double bars without setting the **doubleabsbars** option).

```
\magof{\vect{E}}
```
$\left\|\vec{E}\right\|$

\dimsof{⟨*arg*⟩}
Notation for showing the dimensions of a quantity.

```
\( \dimsof{\vect{v}} = L \cdot T^{-1} \)
```
$[\vec{v}] = L \cdot T^{-1}$

\unitsof{⟨*arg*⟩}
Notation for showing the units of a quantity. I propose this notation and hope to propagate it because I could not find any standard notation for this same idea in other sources.

```
\unitsof{\vect{v}} = \velocityonlytradunit
```
$[\vec{v}]_{u} = \mathrm{m/s}$

\quant{⟨*arg*⟩}
Surrounds the argument with variable sized parentheses. Use \bquant to get square brackets.

```
\quant{\oofpez}
```
$\left(8.9876 \times 10^{9}\,\mathrm{N \cdot m^2/C^2}\right)$

\Changein{⟨*arg*⟩}
Nnotation for *the change in a quantity*.

```
\Changein{\vect{E}}
```
$\Delta\vec{E}$

\scin[⟨*mantissa*⟩]{⟨*exponent*⟩}[⟨*unit*⟩]
Command for scientific notation with an optional unit.

```
\scin[2.99]{8}[\velocityonlytradunit]
```
2.99×10^{8} m/s

\ee{⟨*mantissa*⟩}{⟨*exponent*⟩}
Command for scientific notation for computer code. Use \EE for EE.

```
\ee{2.99}{8}
```
2.99e8

\dms{⟨*deg*⟩}{⟨*min*⟩}{⟨*sec*⟩}
Command for formatting angles and time. Use \hms for time. Note that other packages may do this better.

```
\dms{23}{34}{10.27} \\
\hms{23}{34}{10.27}
```
$23\,^{\circ}34\,'10.27\,''$
$23^{\mathrm{h}}34^{\mathrm{m}}10.27^{\mathrm{s}}$

\clockreading{⟨*hrs*⟩}{⟨*min*⟩}{⟨*sec*⟩}
Command for formatting a clock reading. Really an alias for \hms, but conceptually a very different idea that introductory textbooks don't do a good enough job at articulating.

```
\clockreading{23}{34}{10.27}
```
$23^{\mathrm{h}}34^{\mathrm{m}}10.27^{\mathrm{s}}$

\latitude{⟨*arg*⟩}
Command for formatting latitude, useful in astronomy. Use \latitudeN or \latitudeS to include a letter.

```
\latitude{+35} \latitudeN{35} \latitudeS{35}
```
$+35\,^{\circ}$ $35\,^{\circ}$ N $35\,^{\circ}$ S

\longitude{⟨*arg*⟩}
Command for formatting longitude, useful in astronomy. Use \longitudeE or \longitudeW to include a letter.

```
\longitude{-81} \longitudeE{81} \longitudeW{81}
```
$-81\,^{\circ}$ $81\,^{\circ}$ E $81\,^{\circ}$ W

\ssup{⟨*kernel*⟩}{⟨*sup*⟩}
Command for typesetting text superscripts.

```
\ssup{N}{contact}
```

N^{contact}

\ssub{⟨*kernel*⟩}{⟨*sub*⟩}
Command for typesetting text subscripts.

```
\ssub{N}{AB}
```

N_{AB}

\ssud{⟨*sup*⟩}{⟨*sub*⟩}
Command for typesetting text superscripts and subscripts.

```
\ssud{N}{contact}{AB}
```

$N^{\mathrm{contact}}_{\mathrm{AB}}$

\msup{⟨*kernel*⟩}{⟨*sup*⟩}
Command for typesetting mathematical superscripts.

```
\msup{R}{\gamma}
```

R^{γ}

\msub{⟨*kernel*⟩}{⟨*sub*⟩}
Command for typesetting mathematical subscripts.

```
\msub{R}{\alpha\beta}
```

$R_{\alpha\beta}$

\msud{⟨*kernel*⟩}{⟨*sup*⟩}{⟨*sub*⟩}
Command for typesetting mathematical superscripts and subscripts.

```
\msud{\Gamma}{\gamma}{\alpha\beta}
```

$\Gamma^{\gamma}_{\alpha\beta}$

\levicivita{⟨*indices*⟩}
Command for Levi-Civita symbol.

`\levicivita{ijk}`	ε_{ijk}

`\kronecker{`⟨*indices*⟩`}`
Command for Kronecker delta symbol.

`\kronecker{ij}`	δ_{ij}

`\xaxis`
Command for coordinate axes.

`\xaxis \yaxis \zaxis`	x-axis y-axis z-axis

`\naxis[`⟨*axis*⟩`]`
Command for custom naming a coordinate axis.

`\naxis{t}`	t-axis

`\xyplane`
Commands for naming coordinate planes. All combinations are defined.

`\xyplane \yzplane \zxplane \yxplane \zyplane \xzplane`
xy-plane yz-plane zx-plane yx-plane zy-plane xz-plane

`\fsqrt{`⟨*arg*⟩`}`
Command for square root as a fractional exponent.

`\fsqrt{x}`	$x^{\frac{1}{2}}$

`\cuberoot{`⟨*arg*⟩`}`
Command for cube root of an argument. Use `\fcuberoot` to get fractional exponent.

`\cuberoot{x} \fcuberoot{x}`	$\sqrt[3]{x}$ $x^{\frac{1}{3}}$

\fourthroot{⟨*arg*⟩}
Command for fourth root of an argument. Use **\ffourthroot** to get fractional exponent.

```
\fourthroot{x} \ffourthroot{x}
```

$$\sqrt[4]{x}\ x^{\frac{1}{4}}$$

\fifthroot{⟨*arg*⟩}
Command for fifth root of an argument. Use **\ffifthroot** to get fractional exponent.

```
\fifthroot{x} \ffifthroot{x}
```

$$\sqrt[5]{x}\ x^{\frac{1}{5}}$$

\relgamma{⟨*arg*⟩}
Expression for Lorentz factor. Use **\frelgamma** to get fractional exponent.

```
\begin{align*}
\gamma&=\relgamma{\magvect{v}}\\
\gamma&=\relgamma{(0.5c)}\\
\gamma&=\frelgamma{\magvect{v}}\\
\gamma&=\frelgamma{(0.5c)}
\end{align*}
```

$$\begin{aligned}
\gamma &= \frac{1}{\sqrt{1-\left(\frac{|\vec{v}|}{c}\right)^2}}\\
\gamma &= \frac{1}{\sqrt{1-\left(\frac{(0.5c)}{c}\right)^2}}\\
\gamma &= \left(1-\frac{|\vec{v}|^2}{c^2}\right)^{-\frac{1}{2}}\\
\gamma &= \left(1-\frac{(0.5c)^2}{c^2}\right)^{-\frac{1}{2}}
\end{aligned}$$

\oosqrtomxs{⟨*arg*⟩}
Commands for expressions convenient in numerically evaluating Lorentz factors. Say each expression out loud and you'll see where the command names come from.

```
\oosqrtomxs{0.22}
\oosqrtomx{0.22}
\ooomx{0.22}
\ooopx{0.11}
```

$$\frac{1}{\sqrt{1-0.22^2}}\ \frac{1}{\sqrt{1-0.22}}\ \frac{1}{1-0.22}\ \frac{1}{1+0.11}$$

5.13 Custom Operators

The = operator is frequently misused, and we need other operators for other situations.

\isequals
Command for *test-for-equality* operator.

```
5 \isequals 3
```

$5 \stackrel{?}{=} 3$

\wordoperator{⟨*firstline*⟩}{⟨*secondline*⟩}
Command for two lines of tiny text to be use as an operator without using mathematical symbols. Use \pwordoperator to get parentheses around the operator.

```
\wordoperator{added}{to} \\
\pwordoperator{added}{to}
```

$\underset{\text{to}}{\overset{\text{added}}{}}$
$\left(\underset{\text{to}}{\overset{\text{added}}{}}\right)$

\definedas
Commands for frequently used word operators. Prepend p to each to get parentheses around the operator.

```
\definedas and \associated and \adjustedby     \\
\earlierthan and \laterthan and \forevery      \\
\pdefinedas and \passociated and \padjustedby \\
\pearlierthan and \platerthan and \pforevery
```

$\underset{\text{as}}{\overset{\text{defined}}{}}$ and $\underset{\text{with}}{\overset{\text{associated}}{}}$ and $\underset{\text{by}}{\overset{\text{adjusted}}{}}$
$\underset{\text{than}}{\overset{\text{earlier}}{}}$ and $\underset{\text{than}}{\overset{\text{later}}{}}$ and $\underset{\text{every}}{\overset{\text{for}}{}}$
$\left(\underset{\text{as}}{\overset{\text{defined}}{}}\right)$ and $\left(\underset{\text{with}}{\overset{\text{associated}}{}}\right)$ and $\left(\underset{\text{by}}{\overset{\text{adjusted}}{}}\right)$
$\left(\underset{\text{than}}{\overset{\text{earlier}}{}}\right)$ and $\left(\underset{\text{than}}{\overset{\text{later}}{}}\right)$ and $\left(\underset{\text{every}}{\overset{\text{for}}{}}\right)$

\defines
Command for *defines* or *defined by* operator.

```
\vect{p} \defines \(\gamma m\)\vect{v}
```

$\vec{p} \stackrel{\text{def}}{=} \gamma m \vec{v}$

\inframe[⟨*frame*⟩]
Command for operator indicating the coordinate representation of a vector in a particular reference frame denoted by a capital letter.

Make the arrow's length fixed.

```
\vect{p} \inframe[S] ↩
      {\momentum{\mivector{1,2,3}} \\
\vect{p} \inframe[S'] ↩
      {\momentum{\mivector{\sqrt{14},0,0}}
```

$\vec{p} \underset{\mathcal{S}}{\longrightarrow} \langle 1, 2, 3 \rangle \,\mathrm{kg \cdot m/s}$
$\vec{p} \underset{\mathcal{S}'}{\longrightarrow} \left\langle \sqrt{14}, 0, 0 \right\rangle \,\mathrm{kg \cdot m/s}$

\associates
Command for *associated with* or *associates with* operator (for verbal concepts).

```
kinetic energy \associates velocity
```

kinetic energy $\xrightarrow{\text{assoc}}$ velocity

\becomes
Command for *becomes* operator.

```
\(\gamma m\)\vect{v} \becomes \(m\)\vect{v}
```

$\gamma m\vec{v} \xrightarrow{\text{becomes}} m\vec{v}$

\rrelatedto{⟨*leftoperation*⟩}
Command for left-to-right relationship.

```
(flux ratio) \rrelatedto{taking logarithm} (mag ↪
      ↪diff)
```

(flux ratio) $\xrightarrow{\text{taking logarithm}}$ (mag diff)

\lrelatedto{⟨*roperation*⟩}
Command for right-to-left relationship.

```
(flux ratio) \lrelatedto{exponentiation} (mag ↪
      ↪diff)
```

(flux ratio) $\xleftarrow[\text{exponentiation}]{}$ (mag diff)

\brelatedto{⟨*leftoperation*⟩}{⟨*roperation*⟩}
Command for bidirectional relationship.

```
(mag diff) \brelatedto{taking ↪
      ↪logarithm}{exponentiation}(flux ratio)
```

(mag diff) $\xleftrightarrow[\text{taking logarithm}]{\text{exponentiation}}$(flux ratio)

5.14 Commands Specific to *Matter & Interactions*

\momentumprinciple
Expression for the momentum principle. Prepend \LHS to get just the left hand side and \RHS to get just the right hand side.

```
\momentumprinciple
```

$\vec{p}_{\text{sys,f}} = \vec{p}_{\text{sys,i}} + \vec{F}_{\text{net,sys}}\Delta t$

\energyprinciple
Expression for the energy principle. Prepend \LHS to get just the left hand side and \RHS to get just the right hand side.

`\energyprinciple`	$E_{\text{sys,f}} = E_{\text{sys,i}} + W_{\text{ext}} + Q$

\angularmomentumprinciple
Expression for the angular momentum principle. Prepend \LHS to get just the left hand side and \RHS to get just the right hand side.

`\angularmomentumprinciple`	$\vec{L}_{\text{sys,A,f}} = \vec{L}_{\text{sys,A,i}} + \vec{T}_{\text{net,sys}}\,\Delta t$

\gravitationalinteraction
Expression for gravitational interaction.

`\gravitationalinteraction`	$G\frac{M_1 M_2}{\left\lvert\vec{r}_{12}\right\rvert^2}\left(-\hat{r}_{12}\right)$

\electricinteraction
Expression for electric interaction.

`\electricinteraction`	$\frac{1}{4\pi\epsilon_{\text{o}}}\frac{Q_1 Q_2}{\left\lvert\vec{r}_{12}\right\rvert^2}\hat{r}_{12}$

\Efieldofparticle
Expression for a particle's electric field.

`\Efieldofparticle`	$\frac{1}{4\pi\epsilon_{\text{o}}}\frac{Q}{\left\lvert\vec{r}\right\rvert^2}\hat{r}$

\Bfieldofparticle
Expression for a particle's magnetic field.

`\Bfieldofparticle`	$\frac{\mu_{o}}{4\pi}\frac{Q\left\|\vec{v}\right\|}{\left\|\vec{r}\right\|^{2}}\widehat{v}\times\widehat{r}$

`\Esys`
Symbol for system energy.

`\Esys`	E_{sys}

`\Us`
Symbol for spring potential energy.

`\Us`	U_{s}

`\Ug`
Symbol for gravitational potential energy.

`\Ug`	U_{g}

`\Ue`
Symbol for electric potential energy.

`\Ue`	U_{e}

`\Ktrans`
Symbol for translational kinetic energy.

`\Ktrans`	K_{trans}

`\Krot`
Symbol for rotational kinetic energy.

`\Krot`	K_{rot}

\Eparticle
Symbol for particle energy.

`\Eparticle`	E_{particle}

\Einternal
Symbol for internal energy.

`\Einternal`	E_{internal}

\Erest
Symbol for rest energy.

`\Erest`	E_{rest}

\Echem
Symbol for chemical energy.

`\Echem`	E_{chem}

\Etherm
Symbol for thermal energy.

`\Etherm`	E_{therm}

\Evib
Symbol for vibrational energy.

`\Evib`	E_{vib}

\Ephoton
Symbol for photon energy.

`\Ephoton`	E_{photon}

\DUs
Symbol for change in spring potential energy.

`\DUs`	ΔU_{s}

\DUg
Symbol for change in gravitational potential energy.

`\DUg`	ΔU_{g}

\DUe
Symbol for change in electric potential energy.

`\DUe`	ΔU_{e}

\DKtrans
Symbol for change in translational kinetic energy.

`\DKtrans`	ΔK_{trans}

\DKrot
Symbol for change in rotational kinetic energy.

`\DKrot`	ΔK_{rot}

\DEparticle
Symbol for change in particle energy.

`\DEparticle`	$\Delta E_{\text{particle}}$

\DEinternal
Symbol for change in internal energy.

`\DEinternal`	$\Delta E_{\text{internal}}$

\DErest
Symbol for change in rest energy.

`\DErest`	ΔE_{rest}

\DEchem
Symbol for change in chemical energy.

`\DEchem`	ΔE_{chem}

\DEtherm
Symbol for change in thermal energy.

`\DEtherm`	ΔE_{therm}

\DEvib
Symbol for change in vibrational energy.

`\DEvib`	ΔE_{vib}

\DEphoton
Symbol for change in photon energy.

`\DEphoton`	ΔE_{photon}

\Usfinal
Expression for final spring potential energy.

`\Usfinal`	$\left(\frac{1}{2}k_{s}\,s^{2}\right)_{\mathrm{f}}$

`\Usinitial`
Expression for initial spring potential energy.

`\Usinitial`	$\left(\frac{1}{2}k_{s}\,s^{2}\right)_{\mathrm{i}}$

`\Uefinal`
Expression for final electric potential energy.

`\Uefinal`	$\left(\frac{1}{4\pi\epsilon_{\mathrm{o}}}\frac{Q_{1}Q_{2}}{\left\vert\vec{r}_{12}\right\vert}\right)_{\mathrm{f}}$

`\Ueinitial`
Expression for initial electric potential energy.

`\Ueinitial`	$\left(\frac{1}{4\pi\epsilon_{\mathrm{o}}}\frac{Q_{1}Q_{2}}{\left\vert\vec{r}_{12}\right\vert}\right)_{\mathrm{i}}$

`\Ugfinal`
Expression for final gravitational potential energy.

`\Ugfinal`	$\left(-G\frac{M_{1}M_{2}}{\left\vert\vec{r}_{12}\right\vert}\right)_{\mathrm{f}}$

`\Uginitial`
Expression for initial gravitational potential energy.

`\Uginitial`	$\left(-G\frac{M_{1}M_{2}}{\left\vert\vec{r}_{12}\right\vert}\right)_{\mathrm{i}}$

\ks
Symbol for spring stiffness.

`\ks`	k_s

\Fnet
Various symbols for net force.

`\Fnet \Fnetext \Fnetsys \Fsub{ball,bat}`	$\vec{F}_{\text{net}}\ \vec{F}_{\text{net,ext}}\ \vec{F}_{\text{net,sys}}\ \vec{F}_{\text{ball,bat}}$

\Tnet
Various symbols for net torque.

`\Tnet \Tnetext \Tnetsys \Tsub{ball,bat}`	$\vec{T}_{\text{net}}\ \vec{T}_{\text{net,ext}}\ \vec{T}_{\text{net,sys}}\ \vec{T}_{\text{ball,bat}}$

\vpythonline{⟨*vpythoncode*⟩}
Command for a single line of VPython code used inline.

`\vpythonline{from visual import *}`	**from** visual **import** $*$

\begin{vpythonblock}
⟨*environment content*⟩
\end{vpythonblock}
Environment for a block of VPython code.

```
\begin{vpythonblock}
  from visual import *
  sphere(center=pos(1,2,3),color=color.green)
  MyArrow=arrow(pos=earth.pos, axis=fscale*Fnet, color=color.green)
  print ("arrow.pos = "), arrow.pos
\end{vpythonblock}
```

```
from visual import *
sphere(center=pos(1,2,3),color=color.green)
MyArrow=arrow(pos=earth.pos, axis=fscale*Fnet, color=color.green)
print ("arrow.pos = "), arrow.pos
```

\vpythonfile⟨*filename*⟩

Typesets a file in the current directory containing VPython code.

```
\vpythonfile{vdemo.py}
```

```
from __future__ import print_function, division
from visual import *

giant = sphere(pos=vector(-1e11,0,0),radius=2e10,mass=2e30,color=color.red)
giant.p = vector(0, 0, -1e4) * giant.mass

dwarf = sphere(pos=vector(1.5e11,0,0),radius=1e10,mass=1e30,color=color.yellow)
dwarf.p = -giant.p

for a in [giant, dwarf]:
  a.orbit = curve(color=a.color, radius=2e9)

dt = 86400
while 1:
  rate(100)
  dist = dwarf.pos - giant.pos
  force = 6.7e-11 * giant.mass * dwarf.mass * dist / mag(dist)**3
  giant.p = giant.p + force*dt
  dwarf.p = dwarf.p - force*dt
  for a in [giant, dwarf]:
    a.pos = a.pos + a.p/a.mass * dt
    a.orbit.append(pos=a.pos)
```

5.15 Boxes and Environments

\emptyanswer[⟨*wdth*⟩][⟨*hght*⟩]

Typesets empty space for filling answer boxes, so there is nothing to see.

```
\emptyanswer[0.75][0.2]
```

\begin{activityanswer}[⟨*bgclr*⟩][⟨*frmclr*⟩][⟨*txtclr*⟩][⟨*wdth*⟩][⟨*hght*⟩]
⟨*environment content*⟩

\end{activityanswer}

Main environment for typesetting boxed answers.

```
\begin{activityanswer}
  Lorem ipsum dolor sit amet, consectetuer adipiscing elit.
  Morbi commodo, ipsum sed pharetra gravida, orci magna
  rhoncus neque, id pulvinar odio lorem non turpis. Nullam
  sit amet enim.
\end{activityanswer}
```

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Morbi commodo, ipsum sed pharetra gravida, orci magna rhoncus neque, id pulvinar odio lorem non turpis. Nullam sit amet enim.

\begin{adjactivityanswer}[⟨*bgclr*⟩][⟨*frmclr*⟩][⟨*txtclr*⟩][⟨*wdth*⟩][⟨*hght*⟩]
⟨*environment content*⟩
\end{adjactivityanswer}

Like \activityanswer but adjusts vertically to tightly surround text.

```
\begin{adjactivityanswer}
  Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Morbi
  commodo, ipsum sed pharetra gravida, orci magna rhoncus neque,
  id pulvinar odio lorem non turpis. Nullam sit amet enim.
  Suspendisse id velit vitae ligula volutpat condimentum. Aliquam
  erat volutpat. Sed quis velit. Nulla facilisi. Nulla libero.
  Vivamus pharetra posuere sapien. Nam consectetuer. Sed aliquam,
  nunc eget euismod ullamcorper, lectus nunc ullamcorper orci,
  fermentum bibendum enim nibh eget ipsum. Donec porttitor ligula
  eu dolor. Maecenas vitae nulla consequat libero cursus venenatis.
  Nam magna enim, accumsan eu, blandit sed, blandit a, eros.
\end{adjactivityanswer}
```

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Morbi commodo, ipsum sed pharetra gravida, orci magna rhoncus neque, id pulvinar odio lorem non turpis. Nullam sit amet enim. Suspendisse id velit vitae ligula volutpat condimentum. Aliquam erat volutpat. Sed quis velit. Nulla facilisi. Nulla libero. Vivamus pharetra posuere sapien. Nam consectetuer. Sed aliquam, nunc eget euismod ullamcorper, lectus nunc ullamcorper orci, fermentum bibendum enim nibh eget ipsum. Donec porttitor ligula eu dolor. Maecenas vitae nulla consequat libero cursus venenatis. Nam magna enim, accumsan eu, blandit sed, blandit a, eros.

\emptybox[⟨*txt*⟩][⟨*bgclr*⟩][⟨*frmclr*⟩][⟨*txtclr*⟩][⟨*wdth*⟩][⟨*hght*⟩]

Provides a fixed-size box with optional text.

```
\emptybox[Lorem ipsum dolor sit amet, consectetuer adipiscing elit.
Morbi commodo, ipsum sed pharetra gravida, orci magna rhoncus neque,
id pulvinar odio lorem non turpis. Nullam sit amet enim.]
```

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Morbi commodo, ipsum sed pharetra gravida, orci magna rhoncus neque, id pulvinar odio lorem non turpis. Nullam sit amet enim.

\adjemptybox[⟨*txt*⟩][⟨*bgclr*⟩][⟨*frmclr*⟩][⟨*txtclr*⟩][⟨*wdth*⟩][⟨*hght*⟩]
Like \emptybox but adjusts vertically to tightly surround text.

```
\adjemptybox[Lorem ipsum dolor sit amet, consectetuer adipiscing
elit. Morbi commodo, ipsum sed pharetra gravida, orci magna rhoncus
neque, id pulvinar odio lorem non turpis. Nullam sit amet enim.]
```

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Morbi commodo, ipsum sed pharetra gravida, orci magna rhoncus neque, id pulvinar odio lorem non turpis. Nullam sit amet enim.

\answerbox[⟨*txt*⟩][⟨*bgclr*⟩][⟨*frmclr*⟩][⟨*txtclr*⟩][⟨*wdth*⟩][⟨*hght*⟩]
Wrapper for \emptybox.

```
\answerbox[Lorem ipsum dolor sit amet, consectetuer adipiscing elit.
Morbi commodo, ipsum sed pharetra gravida, orci magna rhoncus neque,
id pulvinar odio lorem non turpis. Nullam sit amet enim.]
```

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Morbi commodo, ipsum sed pharetra gravida, orci magna rhoncus neque, id pulvinar odio lorem non turpis. Nullam sit amet enim.

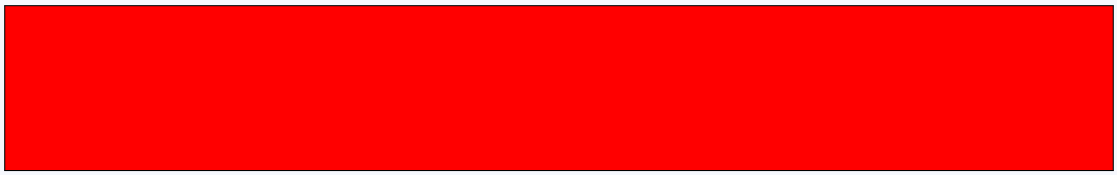
\adjanswerbox[⟨*txt*⟩][⟨*bgclr*⟩][⟨*frmclr*⟩][⟨*txtclr*⟩][⟨*wdth*⟩][⟨*hght*⟩]
Wrapper for \adjemptybox.

```
\adjanswerbox[Lorem ipsum dolor sit amet, consectetuer adipiscing
elit. Morbi commodo, ipsum sed pharetra gravida, orci magna rhoncus
neque, id pulvinar odio lorem non turpis. Nullam sit amet enim.]
```

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Morbi commodo, ipsum sed pharetra gravida, orci magna rhoncus neque, id pulvinar odio lorem non turpis. Nullam sit amet enim.

\smallanswerbox[⟨*txt*⟩][⟨*bgclr*⟩]
Answer box with height 0.10 that of current **\textheight** and width 0.90 that of current **\linewidth**.

```
\smallanswerbox[][red]
```



\mediumanswerbox[⟨*txt*⟩][⟨*bgclr*⟩]
Answer box with height 0.20 that of current **\textheight** and width 0.90 that of current **\linewidth**.

```
\mediumanswerbox[][lightgray]
```

\largeanswerbox[⟨*txt*⟩][⟨*bgclr*⟩]
Answer box with height 0.25 that of current **\textheight** and width 0.90 that of current **\linewidth** (too large to show here).

```
\largeanswerbox[][lightgray]
```

\largeranswerbox[⟨*txt*⟩][⟨*bgclr*⟩]
Answer box with height 0.33 that of current \textheight and width 0.90 that of current \linewidth (too large to show here).

```
\largeranswerbox[][lightgray]
```

\hugeanswerbox[⟨*txt*⟩][⟨*bgclr*⟩]
Answer box with height 0.50 that of current \textheight and width 0.90 that of current \linewidth (too large to show here).

```
\hugeanswerbox[][lightgray]
```

\hugeranswerbox[⟨*txt*⟩][⟨*bgclr*⟩]
Answer box with height 0.75 that of current \textheight and width 0.90 that of current \linewidth (too large to show here).

```
\hugeranswerbox[][lightgray]
```

\fullpageanswerbox[⟨*txt*⟩][⟨*bgclr*⟩]
Answer box with height 1.00 that of current \textheight and width 0.90 that of current \linewidth (too large to show here).

```
\fullpageanswerbox[][lightgray]
```

\begin{miinstructornote}
⟨*environment content*⟩
\end{miinstructornote}
Environment for highlighting notes to instructors.

```
\begin{miinstructornote}
  Nunc auctor bibendum eros. Maecenas porta accumsan mauris. Etiam
  enim enim, elementum sed, bibendum quis, rhoncus non, metus. Fusce
  neque dolor, adipiscing sed, consectetuer et, lacinia sit amet,
  quam. Suspendisse wisi quam, consectetuer in, blandit sed,
  suscipit eu, eros. Etiam ligula enim, tempor ut, blandit nec,
  mollis eu, lectus. Nam cursus. Vivamus iaculis. Aenean risus
  purus, pharetra in, blandit quis, gravida a, turpis. Donec nisl.
  Aenean eget mi. Fusce mattis est id diam. Phasellus faucibus
  interdum sapien.
\end{miinstructornote}
```

INSTRUCTOR NOTE

Nunc auctor bibendum eros. Maecenas porta accumsan mauris. Etiam enim enim, elementum sed, bibendum quis, rhoncus non, metus. Fusce neque dolor, adipiscing sed, consectetuer et, lacinia sit amet, quam. Suspendisse wisi quam, consectetuer in, blandit sed, suscipit eu, eros. Etiam ligula enim, tempor ut, blandit nec, mollis eu, lectus. Nam cursus. Vivamus iaculis. Aenean risus purus, pharetra in, blandit quis, gravida a, turpis. Donec nisl. Aenean eget mi. Fusce mattis est id diam. Phasellus faucibus interdum sapien.

`\begin{mistudentnote}`
  ⟨*environment content*⟩
`\end{mistudentnote}`

Environment for highlighting notes to students.

```
\begin{mistudentnote}
  Nunc auctor bibendum eros. Maecenas porta accumsan mauris. Etiam
  enim enim, elementum sed, bibendum quis, rhoncus non, metus. Fusce
  neque dolor, adipiscing sed, consectetuer et, lacinia sit amet,
  quam. Suspendisse wisi quam, consectetuer in, blandit sed,
  suscipit eu, eros. Etiam ligula enim, tempor ut, blandit nec,
  mollis eu, lectus. Nam cursus. Vivamus iaculis. Aenean risus
  purus, pharetra in, blandit quis, gravida a, turpis. Donec nisl.
  Aenean eget mi. Fusce mattis est id diam. Phasellus faucibus
  interdum sapien.
\end{mistudentnote}
```

STUDENT NOTE

Nunc auctor bibendum eros. Maecenas porta accumsan mauris. Etiam enim enim, elementum sed, bibendum quis, rhoncus non, metus. Fusce neque dolor, adipiscing sed, consectetuer et, lacinia sit amet, quam. Suspendisse wisi quam, consectetuer in, blandit sed, suscipit eu, eros. Etiam ligula enim, tempor ut, blandit nec, mollis eu, lectus. Nam cursus. Vivamus iaculis. Aenean risus purus, pharetra in, blandit quis, gravida a, turpis. Donec nisl. Aenean eget mi. Fusce mattis est id diam. Phasellus faucibus interdum sapien.

`\begin{`**`miderivation`**`}`
  ⟨*environment content*⟩
`\end{`**`miderivation`**`}`

Environment for mathematical derivations based on the `align` environment.

```
\begin{miderivation}
  \gamma &= \relgamma{\magvect{v}}
    && \text{given} \\
  \msup{\gamma}{2}&= \ooomx{\msup{(\frac{\magvect{v}}{c})}{2}}
    &&\text{square both sides}\\
  \frac{1}{\msup{\gamma}{2}}&=1-\msup{(\frac{\magvect{v}}{c})}{2}
    &&\text{reciprocal of both sides} \\
  \msup{(\frac{\magvect{v}}{c})}{2}&=1-\frac{1}{\msup{\gamma}{2}}
    &&\text{rearrange} \\
  \frac{\magvect{v}}{c}&=\sqrt{1-\frac{1}{\msup{\gamma}{2}}}
    &&\text{square root of both sides}
\end{miderivation}
```

DERIVATION

$$\gamma = \frac{1}{\sqrt{1-\left(\frac{|\vec{v}|}{c}\right)^2}} \qquad \text{given}$$

$$\gamma^2 = \frac{1}{1-\left(\frac{|\vec{v}|}{c}\right)^2} \qquad \text{square both sides}$$

$$\frac{1}{\gamma^2} = 1-\left(\frac{|\vec{v}|}{c}\right)^2 \qquad \text{reciprocal of both sides}$$

$$\left(\frac{|\vec{v}|}{c}\right)^2 = 1-\frac{1}{\gamma^2} \qquad \text{rearrange}$$

$$\frac{|\vec{v}|}{c} = \sqrt{1-\frac{1}{\gamma^2}} \qquad \text{square root of both sides}$$

`\begin{bwinstructornote}`
⟨*environment content*⟩
`\end{bwinstructornote}`

Environment for highlighting notes to instructors.

```
\begin{bwinstructornote}
  Nunc auctor bibendum eros. Maecenas porta accumsan mauris. Etiam
  enim enim, elementum sed, bibendum quis, rhoncus non, metus. Fusce
  neque dolor, adipiscing sed, consectetuer et, lacinia sit amet,
  quam. Suspendisse wisi quam, consectetuer in, blandit sed,
  suscipit eu, eros. Etiam ligula enim, tempor ut, blandit nec,
  mollis eu, lectus. Nam cursus. Vivamus iaculis. Aenean risus
  purus, pharetra in, blandit quis, gravida a, turpis. Donec nisl.
  Aenean eget mi. Fusce mattis est id diam. Phasellus faucibus
  interdum sapien.
\end{bwinstructornote}
```

INSTRUCTOR NOTE

Nunc auctor bibendum eros. Maecenas porta accumsan mauris. Etiam enim enim, elementum sed, bibendum quis, rhoncus non, metus. Fusce neque dolor, adipiscing sed, consectetuer et, lacinia sit amet, quam. Suspendisse wisi quam, consectetuer in, blandit sed, suscipit eu, eros. Etiam ligula enim, tempor ut, blandit nec, mollis eu, lectus. Nam cursus. Vivamus iaculis. Aenean risus purus, pharetra in, blandit quis, gravida a, turpis. Donec nisl. Aenean eget mi. Fusce mattis est id diam. Phasellus faucibus interdum sapien.

`\begin{bwstudentnote}`
  ⟨*environment content*⟩
`\end{bwstudentnote}`

Environment for highlighting notes to students.

```
\begin{bwstudentnote}
  Nunc auctor bibendum eros. Maecenas porta accumsan mauris. Etiam
  enim enim, elementum sed, bibendum quis, rhoncus non, metus. Fusce
  neque dolor, adipiscing sed, consectetuer et, lacinia sit amet,
  quam. Suspendisse wisi quam, consectetuer in, blandit sed,
  suscipit eu, eros. Etiam ligula enim, tempor ut, blandit nec,
  mollis eu, lectus. Nam cursus. Vivamus iaculis. Aenean risus
  purus, pharetra in, blandit quis, gravida a, turpis. Donec nisl.
  Aenean eget mi. Fusce mattis est id diam. Phasellus faucibus
  interdum sapien.
\end{bwstudentnote}
```

STUDENT NOTE

Nunc auctor bibendum eros. Maecenas porta accumsan mauris. Etiam enim enim, elementum sed, bibendum quis, rhoncus non, metus. Fusce neque dolor, adipiscing sed, consectetuer et, lacinia sit amet, quam. Suspendisse wisi quam, consectetuer in, blandit sed, suscipit eu, eros. Etiam ligula enim, tempor ut, blandit nec, mollis eu, lectus. Nam cursus. Vivamus iaculis. Aenean risus purus, pharetra in, blandit quis, gravida a, turpis. Donec nisl. Aenean eget mi. Fusce mattis est id diam. Phasellus faucibus interdum sapien.

`\begin{bwderivation}`
  ⟨*environment content*⟩
`\end{bwderivation}`

Environment for mathematical derivations based on the `align` environment.

```
\begin{bwderivation}
  \gamma &= \relgamma{\magvect{v}}
    && \text{given} \\
  \msup{\gamma}{2}&= \ooomx{\msup{(\frac{\magvect{v}}{c})}{2}}
    &&\text{square both sides}\\
  \frac{1}{\msup{\gamma}{2}}&=1-\msup{(\frac{\magvect{v}}{c})}{2}
    &&\text{reciprocal of both sides} \\
  \msup{(\frac{\magvect{v}}{c})}{2}&=1-\frac{1}{\msup{\gamma}{2}}
    &&\text{rearrange} \\
  \frac{\magvect{v}}{c}&=\sqrt{1-\frac{1}{\msup{\gamma}{2}}}
    &&\text{square root of both sides}
\end{bwderivation}
```

DERIVATION

$$\gamma = \frac{1}{\sqrt{1-\left(\frac{|\vec{v}|}{c}\right)^2}} \qquad \text{given}$$

$$\gamma^2 = \frac{1}{1-\left(\frac{|\vec{v}|}{c}\right)^2} \qquad \text{square both sides}$$

$$\frac{1}{\gamma^2} = 1-\left(\frac{|\vec{v}|}{c}\right)^2 \qquad \text{reciprocal of both sides}$$

$$\left(\frac{|\vec{v}|}{c}\right)^2 = 1-\frac{1}{\gamma^2} \qquad \text{rearrange}$$

$$\frac{|\vec{v}|}{c} = \sqrt{1-\frac{1}{\gamma^2}} \qquad \text{square root of both sides}$$

5.16 Miscellaneous Commands

\checkpoint

Centered checkpoint for student discussion.

```
\checkpoint
```

|——— CHECKPOINT ———|

\image{⟨*imagefilename*⟩}{⟨*caption*⟩}

Centered figure displayed actual size with caption.

```
\image{satellite.pdf}{Photograph of satellite}
```

\sneakyone{⟨*thing*⟩}
Sshows factors dividing to a sneaky one.

```
\sneakyone{\m}
```

$$\cancel{\mathrm{m}}^{1}$$

5.17 Experimental Commands

Commands defined in this section are not guaranteed to work consistently and are included for experimental uses only. They may or may not exist in future releases. Most are an attempt to simplify existing commands for subscripted vectors.

Experimental Syntax		Existing Syntax
`\vecto{E}`	$\vec{E}$	`\vect{E}`
`\vecto{E}[ball]`	$\vec{E}_{\mathrm{ball}}$	`\vectsub{E}{ball}`
`\compvecto{E}{y}`	E_{y}	`\compvect{E}{y}`
`\compvecto{E}{x}[ball]`	$E_{x,\mathrm{ball}}$	`\compvectsub{E}{x}{ball}`
`\scompsvecto{E}`	$\left\langle E_{x}, E_{y}, E_{z} \right\rangle$	`\scompsvect{E}`
`\scompsvecto{E}[ball]`	$\left\langle E_{x,\mathrm{ball}}, E_{y,\mathrm{ball}}, E_{z,\mathrm{ball}} \right\rangle$	`\scompsvectsub{E}{ball}`
`\compposo{y}`	y	`\comppos{y}`
`\compposo{y}[ball]`	y_{ball}	`\comppossub{y}{ball}`
`\scompsposo`	$\langle x, y, z \rangle$	`\scompspos`
`\scompsposo[ball]`	$\left\langle x_{\mathrm{ball}}, y_{\mathrm{ball}}, z_{\mathrm{ball}} \right\rangle$	`\scompspossub{ball}`

6 Source Code

Note the packages that must be present.

```
\RequirePackage{amsmath}
\RequirePackage{amssymb}
\RequirePackage{array}
\RequirePackage{bigints}
\RequirePackage{cancel}
\RequirePackage[dvipsnames]{xcolor}
\RequirePackage{environ}
\RequirePackage{etoolbox}
\RequirePackage{filehook}
\RequirePackage{extarrows}
\RequirePackage[T1]{fontenc}
\RequirePackage{graphicx}
\RequirePackage{epstopdf}
\RequirePackage{textcomp}
\RequirePackage{letltxmacro}
\RequirePackage{listings}
\RequirePackage[framemethod=TikZ]{mdframed}
\RequirePackage{suffix}
\RequirePackage{xargs}
\RequirePackage{xparse}
\RequirePackage{xspace}
\RequirePackage{ifthen}
\RequirePackage{calligra}
\DeclareMathAlphabet{\mathcalligra}{T1}{calligra}{m}{n}
\DeclareFontShape{T1}{calligra}{m}{n}{<->s*[2.2]callig15}{}
\DeclareGraphicsRule{.tif}{png}{.png}{`convert #1 `basename #1 .tif`.png}
\DeclareMathAlphabet{\mathpzc}{OT1}{pzc}{m}{it}
\usetikzlibrary{shadows}
\definecolor{vpythoncolor}{rgb}{0.95,0.95,0.95}
\newcommand{\lstvpython}{\lstset{language=Python,numbers=left,numberstyle=\tiny,
  backgroundcolor=\color{vpythoncolor},upquote=true,breaklines}}
\newcolumntype{C}[1]{>{\centering}m{#1}}
\newboolean{@optitalicvectors}
\newboolean{@optdoubleabsbars}
\newboolean{@optbaseunits}
\newboolean{@optdrvdunits}
\setboolean{@optitalicvectors}{false}
\setboolean{@optdoubleabsbars}{false}
\setboolean{@optbaseunits}{false}
\setboolean{@optdrvdunits}{false}
\DeclareOption{italicvectors}{\setboolean{@optitalicvectors}{true}}
\DeclareOption{doubleabsbars}{\setboolean{@optdoubleabsbars}{true}}
\DeclareOption{baseunits}{\setboolean{@optbaseunits}{true}}
\DeclareOption{drvdunits}{\setboolean{@optdrvdunits}{true}}
\ProcessOptions\relax
```

This block of code fixes a conflict with the amssymb package.

```
\@ifpackageloaded{amssymb}{%
  \csundef{square}
  \typeout{mandi: Package amssymb detected. Its \protect\square\space has been redefined.}
}{%
  \typeout{mandi: Package amssymb not detected.}
}%
```

This block of code defines unit names and symbols.

```
\newcommand{\per}{\ensuremath{/}}
\newcommand{\usk}{\ensuremath{\cdot}}
\newcommand{\unit}[2]{\ensuremath{{#1}\,{#2}}}
\newcommand{\ampere}{\ensuremath{\mathrm{A}}}
\newcommand{\arcminute}{\ensuremath{'}}
\newcommand{\arcsecond}{\ensuremath{''}}
\newcommand{\atomicmassunit}{\ensuremath{\mathrm{u}}}
\newcommand{\candela}{\ensuremath{\mathrm{cd}}}
\newcommand{\coulomb}{\ensuremath{\mathrm{C}}}
\newcommand{\degree}{\ensuremath{^{\circ}}}
\newcommand{\electronvolt}{\ensuremath{\mathrm{eV}}}
\newcommand{\eV}{\electronvolt}
\newcommand{\farad}{\ensuremath{\mathrm{F}}}
\newcommand{\henry}{\ensuremath{\mathrm{H}}}
\newcommand{\hertz}{\ensuremath{\mathrm{Hz}}}
\newcommand{\hour}{\ensuremath{\mathrm{h}}}
\newcommand{\joule}{\ensuremath{\mathrm{J}}}
\newcommand{\kelvin}{\ensuremath{\mathrm{K}}}
\newcommand{\kilogram}{\ensuremath{\mathrm{kg}}}
\newcommand{\metre}{\ensuremath{\mathrm{m}}}
\newcommand{\minute}{\ensuremath{\mathrm{min}}}
\newcommand{\mole}{\ensuremath{\mathrm{mol}}}
\newcommand{\newton}{\ensuremath{\mathrm{N}}}
\newcommand{\ohm}{\ensuremath{\Omega}}
\newcommand{\pascal}{\ensuremath{\mathrm{Pa}}}
\newcommand{\radian}{\ensuremath{\mathrm{rad}}}
\newcommand{\second}{\ensuremath{\mathrm{s}}}
\newcommand{\siemens}{\ensuremath{\mathrm{S}}}
\newcommand{\steradian}{\ensuremath{\mathrm{sr}}}
\newcommand{\tesla}{\ensuremath{\mathrm{T}}}
\newcommand{\volt}{\ensuremath{\mathrm{V}}}
\newcommand{\watt}{\ensuremath{\mathrm{W}}}
\newcommand{\weber}{\ensuremath{\mathrm{Wb}}}
\newcommand{\C}{\coulomb}
\newcommand{\F}{\farad}
%\H is already defined as a LaTeX accent
\newcommand{\J}{\joule}
\newcommand{\N}{\newton}
\newcommand{\Pa}{\pascal}
\newcommand{\rad}{\radian}
\newcommand{\sr}{\steradian}
%\S is already defined as a LaTeX symbol
```

```
\newcommand{\T}{\tesla}
\newcommand{\V}{\volt}
\newcommand{\W}{\watt}
\newcommand{\Wb}{\weber}
\newcommand{\square}[1]{\ensuremath{\mathrm{#1}^{2}}}              % prefix   2
\newcommand*{\cubic}[1]{\ensuremath{\mathrm{#1}^{3}}}              % prefix   3
\newcommand*{\quartic}[1]{\ensuremath{\mathrm{#1}^{4}}}            % prefix   4
\newcommand*{\reciprocal}[1]{\ensuremath{\mathrm{#1}^{-1}}}        % prefix  -1
\newcommand*{\reciprocalsquare}[1]{\ensuremath{\mathrm{#1}^{-2}}}  % prefix  -2
\newcommand*{\reciprocalcubic}[1]{\ensuremath{\mathrm{#1}^{-3}}}   % prefix  -3
\newcommand*{\reciprocalquartic}[1]{\ensuremath{\mathrm{#1}^{-4}}} % prefix  -4
\newcommand*{\squared}{\ensuremath{^{\mathrm{2}}}}                 % postfix  2
\newcommand*{\cubed}{\ensuremath{^{\mathrm{3}}}}                   % postfix  3
\newcommand*{\quarted}{\ensuremath{^{\mathrm{4}}}}                 % postfix  4
\newcommand*{\reciprocaled}{\ensuremath{^{\mathrm{-1}}}}           % postfix -1
\newcommand*{\reciprocalsquared}{\ensuremath{^{\mathrm{-2}}}}      % postfix -2
\newcommand*{\reciprocalcubed}{\ensuremath{^{\mathrm{-3}}}}        % postfix -3
\newcommand*{\reciprocalquarted}{\ensuremath{^{\mathrm{-4}}}}      % postfix -4
```

Define a new named physics quantity or physical constant and commands for selecting units. My thanks to Ulrich Diez for contributing this code.

```
\newcommand\mi@exchangeargs[2]{#2#1}%
\newcommand\mi@name{}%
\long\def\mi@name#1#{\romannumeral0\mi@innername{#1}}%
\newcommand\mi@innername[2]{%
  \expandafter\mi@exchangeargs\expandafter{\csname#2\endcsname}{#1}}%
\begingroup
\@firstofone{%
  \endgroup
  \newcommand\mi@forkifnull[3]{%
    \romannumeral\iffalse{\fi\expandafter\@secondoftwo\expandafter
    {\expandafter{\string#1}\expandafter\@secondoftwo\string}%
    \expandafter\@firstoftwo\expandafter{\iffalse}\fi0 #3}{0 #2}}}%
\newcommand\selectbaseunit[3]{#1}
\newcommand\selectdrvdunit[3]{#2}
\newcommand\selecttradunit[3]{#3}
\newcommand\selectunit{}
\newcommand\perpusebaseunit{\let\selectunit=\selectbaseunit}
\newcommand\perpusedrvdunit{\let\selectunit=\selectdrvdunit}
\newcommand\perpusetradunit{\let\selectunit=\selecttradunit}
\newcommand\hereusebaseunit[1]{%
  \begingroup\perpusebaseunit#1\endgroup}%
\newcommand\hereusedrvdunit[1]{%
  \begingroup\perpusedrvdunit#1\endgroup}%
\newcommand\hereusetradunit[1]{%
  \begingroup\perpusetradunit#1\endgroup}%
\newenvironment{usebaseunit}{\perpusebaseunit}{}%
\newenvironment{usedrvdunit}{\perpusedrvdunit}{}%
\newenvironment{usetradunit}{\perpusetradunit}{}%
\newcommand*\newphysicsquantity{\definephysicsquantity{\newcommand}}
\newcommand*\redefinephysicsquantity{\definephysicsquantity{\renewcommand}}
```

```
\newcommandx\definephysicsquantity[5][4=,5=]{%
  \innerdefinewhatsoeverquantityfork{#3}{#4}{#5}{#1}{#2}{}{[1]}{##1}}%
\newcommand*\newphysicsconstant{\definephysicsconstant{\newcommand}}
\newcommand*\redefinephysicsconstant{\definephysicsconstant{\renewcommand}}
\newcommandx\definephysicsconstant[7][6=,7=]{%
  \innerdefinewhatsoeverquantityfork{#5}{#6}{#7}{#1}{#2}{#3}{}{#4}}%
\newcommand\innerdefinewhatsoeverquantityfork[3]{%
  \expandafter\innerdefinewhatsoeverquantity\romannumeral0%
  \mi@forkifnull{#3}{\mi@forkifnull{#2}{{#1}}{{#2}}{#1}}%
                  {\mi@forkifnull{#2}{{#1}}{{#2}}{#3}}{#1}}%
\newcommand\innerdefinewhatsoeverquantity[8]{%
  \mi@name#4{#5}#7{\ensuremath{\unit{#8}{\selectunit{#3}{#1}{#2}}}}%
  \mi@name#4{#5baseunit}#7{\ensuremath{\unit{#8}{#3}}}%
  \mi@name#4{#5drvdunit}#7{\ensuremath{\unit{#8}{#1}}}%
  \mi@name#4{#5tradunit}#7{\ensuremath{\unit{#8}{#2}}}%
  \mi@name#4{#5onlyunit}{\ensuremath{\selectunit{#3}{#1}{#2}}}%
  \mi@name#4{#5onlybaseunit}{\ensuremath{#3}}%
  \mi@name#4{#5onlydrvdunit}{\ensuremath{#1}}%
  \mi@name#4{#5onlytradunit}{\ensuremath{#2}}%
  \mi@name#4{#5value}#7{\ensuremath{#8}}%
  \mi@forkifnull{#7}{%
    \ifx#4\renewcommand\mi@name\let{#5mathsymbol}=\relax\fi
    \mi@name\newcommand{#5mathsymbol}{\ensuremath{#6}}}{}}%
```

This block of code processes the options.

```
\ifthenelse{\boolean{@optitalicvectors}}
  {\typeout{mandi: You'll get italic vector kernels.}}
  {\typeout{mandi: You'll get Roman vector kernels.}}
\ifthenelse{\boolean{@optdoubleabsbars}}
  {\typeout{mandi: You'll get double absolute value bars.}}
  {\typeout{mandi: You'll get single absolute value bars.}}
\ifthenelse{\boolean{@optbaseunits}}
  {\perpusebaseunit %
   \typeout{mandi: You'll get base units.}}
  {\ifthenelse{\boolean{@optdrvdunits}}
     {\perpusedrvdunit %
      \typeout{mandi: You'll get derived units.}}
     {\perpusetradunit %
      \typeout{mandi: You'll get traditional units.}}}
```

This block of code makes parentheses adjustable.

```
\def\resetMathstrut@{%
  \setbox\z@\hbox{%
    \mathchardef\@tempa\mathcode`\[\relax
    \def\@tempb##1"##2##3{\the\textfont"##3\char"}%
    \expandafter\@tempb\meaning\@tempa \relax}%
  \ht\Mathstrutbox@\ht\z@ \dp\Mathstrutbox@\dp\z@}
\begingroup
  \catcode`(\active \xdef({\left\string(}
  \catcode`)\active \xdef){\right\string)}
\endgroup
```

```
\mathcode`(="8000 \mathcode`)="8000
\typeout{mandi: parentheses made adjustable in math mode.}
```

This block of code fixes square root symbol.

```
\let\oldr@@t\r@@t
\def\r@@t#1#2{%
\setbox0=\hbox{\(\oldr@@t#1{#2\,}\)}\dimen0=\ht0
\advance\dimen0-0.2\ht0
\setbox2=\hbox{\vrule height\ht0 depth -\dimen0}%
{\box0\lower0.4pt\box2}}
\LetLtxMacro{\oldsqrt}{\sqrt}
\renewcommand*{\sqrt}[2][\relax]{\oldsqrt[#1]{#2}}
\typeout{mandi: square root symbol fixed.}
```

SI base unit of length or spatial displacement

```
\newcommand{\m}{\metre}
```

SI base unit of mass

```
\newcommand{\kg}{\kilogram}
```

SI base unit of time or temporal displacement

```
\newcommand{\s}{\second}
```

SI base unit of electric current

```
\newcommand{\A}{\ampere}
```

SI base unit of thermodynamic temperature

```
\newcommand{\K}{\kelvin}
```

SI base unit of amount

```
\newcommand{\mol}{\mole}
```

SI base unit of luminous intensity

```
\newcommand{\cd}{\candela}
```

```
\newphysicsquantity{displacement}{\m}[\m][\m]
\newphysicsquantity{mass}{\kg}[\kg][\kg]
\newphysicsquantity{duration}{\s}[\s][\s]
\newphysicsquantity{current}{\A}[\A][\A]
\newphysicsquantity{temperature}{\K}[\K][\K]
\newphysicsquantity{amount}{\mol}[\mol][\mol]
\newphysicsquantity{luminous}{\cd}[\cd][\cd]
\newphysicsquantity{planeangle}{\m\usk\reciprocal\m}[\rad][\rad]
\newphysicsquantity{solidangle}{\m\squared\usk\reciprocalsquare\m}[\sr][\sr]
\newcommand{\indegrees}[1]{\ensuremath{\unit{#1}{\degree}}}
\newcommand{\inFarenheit}[1]{\ensuremath{\unit{#1}{\degree\mathrm{F}}}}
\newcommand{\inCelsius}[1]{\ensuremath{\unit{#1}{\degree\mathrm{C}}}}
\newcommand{\inarcminutes}[1]{\ensuremath{\unit{#1}{\arcminute}}}
\newcommand{\inarcseconds}[1]{\ensuremath{\unit{#1}{\arcsecond}}}
\newcommand{\ineV}[1]{\ensuremath{\unit{#1}{\electronvolt}}}
\newcommand{\inMeVocs}[1]{\ensuremath{\unit{#1}{\mathrm{MeV}\per\msup{c}{2}}}}
\newcommand{\inMeVoc}[1]{\ensuremath{\unit{#1}{\mathrm{MeV}\per c}}}
\newcommand{\inAU}[1]{\ensuremath{\unit{#1}{\mathrm{AU}}}}
\newcommand{\inly}[1]{\ensuremath{\unit{#1}{\mathrm{ly}}}}
```

```
\newcommand{\incyr}[1]{\ensuremath{\unit{#1}{c\usk\mathrm{year}}}}
\newcommand{\inpc}[1]{\ensuremath{\unit{#1}{\mathrm{pc}}}}
\newcommand{\insolarL}[1]{\ensuremath{\unit{#1}{\Lsolar}}}
\newcommand{\insolarT}[1]{\ensuremath{\unit{#1}{\Tsolar}}}
\newcommand{\insolarR}[1]{\ensuremath{\unit{#1}{\Rsolar}}}
\newcommand{\insolarM}[1]{\ensuremath{\unit{#1}{\Msolar}}}
\newcommand{\insolarF}[1]{\ensuremath{\unit{#1}{\Fsolar}}}
\newcommand{\insolarf}[1]{\ensuremath{\unit{#1}{\fsolar}}}
\newcommand{\insolarMag}[1]{\ensuremath{\unit{#1}{\Magsolar}}}
\newcommand{\insolarmag}[1]{\ensuremath{\unit{#1}{\magsolar}}}
\newcommand{\insolarD}[1]{\ensuremath{\unit{#1}{\Dsolar}}}
\newcommand{\insolard}[1]{\ensuremath{\unit{#1}{\dsolar}}}
\newcommand{\velocityc}[1]{\ensuremath{#1c}}
\newphysicsquantity{velocity}{\m\usk\reciprocal\s}[\m\usk\reciprocal\s][\m\per\s]
\newphysicsquantity{acceleration}{\m\usk\s\reciprocalsquared}[\N\per\kg][\m\per\s\squared]
\newcommand{\lorentz}[1]{\ensuremath{#1}}
\newphysicsquantity{momentum}{\m\usk\kg\usk\reciprocal\s}[\N\usk\s][\kg\usk\m\per\s]
\newphysicsquantity{impulse}{\m\usk\kg\usk\reciprocal\s}[\N\usk\s][\kg\usk\m\per\s]
\newphysicsquantity{force}{\m\usk\kg\usk\s\reciprocalsquared}[\N][\N]
\newphysicsquantity{springstiffness}{\kg\usk\s\reciprocalsquared}[\N\per\m][\N\per\m]
\newphysicsquantity{springstretch}{\m}
\newphysicsquantity{area}{\m\squared}
\newphysicsquantity{volume}{\cubic\m}
\newphysicsquantity{linearmassdensity}{\reciprocal\m\usk\kg}[\kg\per\m][\kg\per\m]
\newphysicsquantity{areamassdensity}{\m\reciprocalsquared\usk\kg}[\kg\per\m\squared]
[\kg\per\m\squared]
\newphysicsquantity{volumemassdensity}{\m\reciprocalcubed\usk\kg}[\kg\per\m\cubed]
[\kg\per\m\cubed]
\newphysicsquantity{youngsmodulus}{\reciprocal\m\usk\kg\usk\s\reciprocalsquared}
[\N\per\m\squared][\Pa]
\newphysicsquantity{work}{\m\squared\usk\kg\usk\s\reciprocalsquared}[\J][\N\usk\m]
\newphysicsquantity{energy}{\m\squared\usk\kg\usk\s\reciprocalsquared}[\J][\N\usk\m]
\newphysicsquantity{power}{\m\squared\usk\kg\usk\s\reciprocalcubed}[\W][\J\per\s]
\newphysicsquantity{angularvelocity}{\rad\usk\reciprocal\s}[\rad\per\s][\rad\per\s]
\newphysicsquantity{angularacceleration}{\rad\usk\s\reciprocalsquared}[\rad\per\s\squared]
[\rad\per\s\squared]
\newphysicsquantity{angularmomentum}{\m\squared\usk\kg\usk\reciprocal\s}[\J\usk\s]
[\kg\usk\m\squared\per\s]
\newphysicsquantity{momentofinertia}{\m\squared\usk\kg}[\J\usk\s\squared][\kg\usk\m\squared]
\newphysicsquantity{torque}{\m\squared\usk\kg\usk\s\reciprocalsquared}[\J\per\rad][\N\usk\m]
\newphysicsquantity{entropy}{\m\squared\usk\kg\usk\s\reciprocalsquared\usk\reciprocal\K}
[\J\per\K][\J\per\K]
\newphysicsquantity{wavelength}{\m}[\m][\m]
\newphysicsquantity{wavenumber}{\reciprocal\m}[\per\m][\per\m]
\newphysicsquantity{frequency}{\reciprocal\s}[\hertz][\hertz]
\newphysicsquantity{angularfrequency}{\rad\usk\reciprocal\s}[\rad\per\s][\rad\per\s]
\newphysicsquantity{charge}{\A\usk\s}[\C][\C]
\newphysicsquantity{permittivity}
{\m\reciprocalcubed\usk\reciprocal\kg\usk\s\reciprocalquarted\usk\A\squared}
[\F\per\m][\C\squared\per\N\usk\m\squared]
```

```
\newphysicsquantity{permeability}
{\m\usk\kg\usk\s\reciprocalsquared\usk\A\reciprocalsquared}[\henry\per\m][\T\usk\m\per\A]
\newphysicsquantity{electricfield}{\m\usk\kg\usk\s\reciprocalcubed\usk\reciprocal\A}
[\V\per\m][\N\per\C]
\newphysicsquantity{electricdipolemoment}{\m\usk\s\usk\A}[\C\usk\m][\C\usk\m]
\newphysicsquantity{electricflux}{\m\cubed\usk\kg\usk\s\reciprocalcubed\usk\reciprocal\A}
[\V\usk\m][\N\usk\m\squared\per\C]
\newphysicsquantity{magneticfield}{\kg\usk\s\reciprocalsquared\usk\reciprocal\A}[\T]
[\N\per\C\usk(\m\per\s)] % also \Wb\per\m\squared
\newphysicsquantity{magneticflux}
{\m\squared\usk\kg\usk\s\reciprocalsquared\usk\reciprocal\A}[\volt\usk\s]
[\T\usk\m\squared] % also \Wb and \J\per\A
\newphysicsquantity{cmagneticfield}{\m\usk\kg\usk\s\reciprocalcubed\usk\reciprocal\A}
[\V\per\m][\N\per\C]
\newphysicsquantity{linearchargedensity}{\reciprocal\m\usk\s\usk\A}[\C\per\m][\C\per\m]
\newphysicsquantity{areachargedensity}{\reciprocalsquare\m\usk\s\usk\A}
[\C\per\square\m][\C\per\square\m]
\newphysicsquantity{volumechargedensity}{\reciprocalcubic\m\usk\s\usk\A}
[\C\per\cubic\m][\C\per\cubic\m]
\newphysicsquantity{mobility}
{\m\squared\usk\kg\usk\s\reciprocalquarted\usk\reciprocal\A}[\m\squared\per\volt\usk\s]
[(\m\per\s)\per(\N\per\C)]
\newphysicsquantity{numberdensity}{\reciprocalcubic\m}[\per\cubic\m][\per\cubic\m]
\newphysicsquantity{polarizability}{\reciprocal\kg\usk\s\quarted\usk\square\A}
[\C\usk\square\m\per\V][\C\usk\m\per(\N\per\C)]
\newphysicsquantity{electricpotential}
{\square\m\usk\kg\usk\reciprocalcubic\s\usk\reciprocal\A}[\J\per\C][\V]
\newphysicsquantity{emf}{\square\m\usk\kg\usk\reciprocalcubic\s\usk\reciprocal\A}
[\J\per\C][\V]
\newphysicsquantity{dielectricconstant}{}[][]
\newphysicsquantity{indexofrefraction}{}[][]
\newphysicsquantity{relativepermittivity}{}[][]
\newphysicsquantity{relativepermeability}{}[][]
\newphysicsquantity{energydensity}{\m\reciprocaled\usk\kg\usk\reciprocalsquare\s}
[\J\per\cubic\m][\J\per\cubic\m]
\newphysicsquantity{energyflux}{\kg\usk\s\reciprocalcubed}
[\W\per\m\squared][\W\per\m\squared]
\newphysicsquantity{electroncurrent}{\reciprocal\s}
[\ensuremath{\mathrm{e}}\per\s][\ensuremath{\mathrm{e}}\per\s]
\newphysicsquantity{conventionalcurrent}{\A}[\C\per\s][\A]
\newphysicsquantity{magneticdipolemoment}{\square\m\usk\A}[\J\per\T][\A\usk\square\m]
\newphysicsquantity{currentdensity}{\reciprocalsquare\m\usk\A}[\C\usk\s\per\square\m]
[\A\per\square\m]
\newphysicsquantity{capacitance}
{\reciprocalsquare\m\usk\reciprocal\kg\usk\quartic\s\usk\square\A}[\F][\C\per\V]
% also \C\squared\per\N\usk\m, \s\per\ohm
\newphysicsquantity{inductance}
{\square\m\usk\kg\usk\reciprocalsquare\s\usk\reciprocalsquare\A}[\henry]
[\volt\usk\s\per\A] % also \square\m\usk\kg\per\C\squared, \Wb\per\A
\newphysicsquantity{conductivity}
```

```
{\reciprocalcubic\m\usk\reciprocal\kg\usk\cubic\s\usk\square\A}[\siemens\per\m]
[(\A\per\square\m)\per(\V\per\m)]
\newphysicsquantity{resistivity}
{\cubic\m\usk\kg\usk\reciprocalcubic\s\usk\reciprocalsquare\A}[\ohm\usk\m]
[(\V\per\m)\per(\A\per\square\m)]
\newphysicsquantity{resistance}
{\square\m\usk\kg\usk\reciprocalcubic\s\usk\reciprocalsquare\A}[\V\per\A][\ohm]
\newphysicsquantity{conductance}
{\reciprocalsquare\m\usk\reciprocal\kg\usk\cubic\s\usk\square\A}[\A\per\V][\siemens]
\newphysicsquantity{magneticcharge}{\m\usk\A}[\m\usk\A][\m\usk\A]
\newcommand{\lv}{\ensuremath{\left\langle}}
\newcommand{\rv}{\ensuremath{\right\rangle}}
\newcommand{\symvect}{\mivector}
\newcommand{\ncompsvect}{\mivector}
\ExplSyntaxOn % Written in LaTeX3
\NewDocumentCommand{\magvectncomps}{ m O{} }
  {%
    \sum_of_squares:nn { #1 }{ #2 }
  }%
\cs_new:Npn \sum_of_squares:nn #1 #2
  {%
    \tl_if_empty:nTF { #2 }
      {%
        \clist_set:Nn \l_tmpa_clist { #1 }
        \ensuremath{%
          \sqrt{(\clist_use:Nnnn \l_tmpa_clist { )^2+( } { )^2+( } { )^2+( } )^2 }
        }%
      }%
      {%
        \clist_set:Nn \l_tmpa_clist { #1 }
        \ensuremath{%
          \sqrt{(\clist_use:Nnnn \l_tmpa_clist {\;{ #2 })^2+(} {\;{ #2 })^2+(}
          {\;{ #2 })^2+(} \;{ #2 })^2}
        }%
      }%
  }%
\ExplSyntaxOff
%
\newcommand{\zerovect}{\vect{0}}
\newcommand{\ncompszerovect}{\mivector{0,0,0}}
\ifthenelse{\boolean{@optitalicvectors}}
  {\newcommand{\vect}[1]{\ensuremath{\vec{#1}}}}
  {\newcommand{\vect}[1]{\ensuremath{\vec{\mathrm{#1}}}}}
\ifthenelse{\boolean{@optdoubleabsbars}}
  {\newcommand{\magvect}[1]{\ensuremath{\magof{\vect{#1}}}}}
  {\newcommand{\magvect}[1]{\ensuremath{\abs{\vect{#1}}}}}
\newcommand{\dmagvect}[1]{\ensuremath{\dx{\magvect{#1}}}}
\newcommand{\Dmagvect}[1]{\ensuremath{\Delta\!\magvect{#1}}}
\ifthenelse{\boolean{@optitalicvectors}}
  {\newcommand{\dirvect}[1]{\ensuremath{\widehat{{#1}}}}}
```

```
  {\newcommand{\dirvect}[1]{\ensuremath{\widehat{\mathrm{#1}}}}}
\ifthenelse{\boolean{@optitalicvectors}}
  {\newcommand{\compvect}[2]{\ensuremath{\ssub{#1}{\(#2\)}}}}
  {\newcommand{\compvect}[2]{\ensuremath{\ssub{\mathrm{#1}}{\(#2\)}}}}
\newcommand{\scompsvect}[1]{\ensuremath{\lv
  \compvect{#1}{x},
  \compvect{#1}{y},
  \compvect{#1}{z}\rv}}
\newcommand{\magvectscomps}[1]{\ensuremath{\sqrt{
  \msup{\compvect{#1}{x}}{2}+
  \msup{\compvect{#1}{y}}{2}+
  \msup{\compvect{#1}{z}}{2}}}}
\newcommand{\dvect}[1]{\ensuremath{\mathrm{d}\vect{#1}}}
\newcommand{\Dvect}[1]{\ensuremath{\Delta\vect{#1}}}
\newcommand{\dirdvect}[1]{\ensuremath{\widehat{\dvect{#1}}}}
\newcommand{\dirDvect}[1]{\ensuremath{\widehat{\Dvect{#1}}}}
\newcommand{\ddirvect}[1]{\ensuremath{\mathrm{d}\dirvect{E}}}
\newcommand{\Ddirvect}[1]{\ensuremath{\Delta\dirvect{E}}}
\ifthenelse{\boolean{@optdoubleabsbars}}
  {\newcommand{\magdvect}[1]{\ensuremath{\magof{\dvect{#1}}}}
   \newcommand{\magDvect}[1]{\ensuremath{\magof{\Dvect{#1}}}}}
  {\newcommand{\magdvect}[1]{\ensuremath{\abs{\dvect{#1}}}}
   \newcommand{\magDvect}[1]{\ensuremath{\abs{\Dvect{#1}}}}}
\newcommand{\compdvect}[2]{\ensuremath{\mathrm{d}\compvect{#1}{#2}}}
\newcommand{\compDvect}[2]{\ensuremath{\Delta\compvect{#1}{#2}}}
\newcommand{\scompsdvect}[1]{\ensuremath{\lv
  \compdvect{#1}{x},
  \compdvect{#1}{y},
  \compdvect{#1}{z}\rv}}
\newcommand{\scompsDvect}[1]{\ensuremath{\lv
  \compDvect{#1}{x},
  \compDvect{#1}{y},
  \compDvect{#1}{z}\rv}}
\newcommand{\dervect}[2]{\ensuremath{\frac{\dvect{#1}}{\mathrm{d}{#2}}}}
\newcommand{\Dervect}[2]{\ensuremath{\frac{\Dvect{#1}}{\Delta{#2}}}}
\newcommand{\compdervect}[3]{\ensuremath{\dbyd{\compvect{#1}{#2}}{#3}}}
\newcommand{\compDervect}[3]{\ensuremath{\DbyD{\compvect{#1}{#2}}{#3}}}
\newcommand{\scompsdervect}[2]{\ensuremath{\lv
  \compdervect{#1}{x}{#2},
  \compdervect{#1}{y}{#2},
  \compdervect{#1}{z}{#2}\rv}}
\newcommand{\scompsDervect}[2]{\ensuremath{\lv
  \compDervect{#1}{x}{#2},
  \compDervect{#1}{y}{#2},
  \compDervect{#1}{z}{#2}\rv}}
\ifthenelse{\boolean{@optdoubleabsbars}}
  {\newcommand{\magdervect}[2]{\ensuremath{\magof{\dervect{#1}{#2}}}}
   \newcommand{\magDervect}[2]{\ensuremath{\magof{\Dervect{#1}{#2}}}}}
  {\newcommand{\magdervect}[2]{\ensuremath{\abs{\dervect{#1}{#2}}}}
   \newcommand{\magDervect}[2]{\ensuremath{\abs{\Dervect{#1}{#2}}}}}
```

```
\newcommand{\dermagvect}[2]{\ensuremath{\dbyd{\magvect{#1}}{#2}}}
\newcommand{\Dermagvect}[2]{\ensuremath{\DbyD{\magvect{#1}}{#2}}}
\newcommand{\scompspos}{\mivector{x,y,z}}
\newcommand{\comppos}[1]{\ensuremath{{#1}}}
\newcommand{\scompsdpos}{\mivector{\mathrm{d}x,\mathrm{d}y,\mathrm{d}z}}
\newcommand{\scompsDpos}{\mivector{\Delta x,\Delta y,\Delta z}}
\newcommand{\compdpos}[1]{\ensuremath{\mathrm{d}{#1}}}
\newcommand{\compDpos}[1]{\ensuremath{\Delta{#1}}}
\newcommand{\scompsderpos}[1]{\ensuremath{\lv
  \frac{\mathrm{d}x}{\mathrm{d}{#1}},\frac{\mathrm{d}y}{\mathrm{d}{#1}},
    \frac{\mathrm{d}z}{\mathrm{d}{#1}}\rv}}
\newcommand{\scompsDerpos}[1]{\ensuremath{\lv
  \frac{\Delta x}{\Delta{#1}},\frac{\Delta y}{\Delta{#1}},
    \frac{\Delta z}{\Delta{#1}}\rv}}
\newcommand{\compderpos}[2]{\ensuremath{\frac{\mathrm{d}{#1}}{\mathrm{d}{#2}}}}
\newcommand{\compDerpos}[2]{\ensuremath{\frac{\Delta{#1}}{\Delta{#2}}}}
\newcommand{\vectsub}[2]{\ensuremath{\ssub{\vect{#1}}{#2}}}
\ifthenelse{\boolean{@optitalicvectors}}
  {\newcommand{\compvectsub}[3]{\ensuremath{\ssub{#1}{\(#2\),#3}}}}
  {\newcommand{\compvectsub}[3]{\ensuremath{\ssub{\mathrm{#1}}{\(#2\),#3}}}}
\newcommand{\scompsvectsub}[2]{\ensuremath{\lv
  \compvectsub{#1}{x}{#2},
  \compvectsub{#1}{y}{#2},
  \compvectsub{#1}{z}{#2}\rv}}
\ifthenelse{\boolean{@optdoubleabsbars}}
  {\newcommand{\magvectsub}[2]{\ensuremath{\magof{\vectsub{#1}{#2}}}}}
  {\newcommand{\magvectsub}[2]{\ensuremath{\abs{\vectsub{#1}{#2}}}}}
\newcommand{\magvectsubscomps}[2]{\ensuremath{\sqrt{
    \msup{\compvectsub{#1}{x}{#2}}{2}+
    \msup{\compvectsub{#1}{y}{#2}}{2}+
    \msup{\compvectsub{#1}{z}{#2}}{2}}}}
\ifthenelse{\boolean{@optitalicvectors}}
  {\newcommand{\dirvectsub}[2]{\ensuremath{\ssub{\widehat{#1}}{#2}}}}
  {\newcommand{\dirvectsub}[2]{\ensuremath{\ssub{\widehat{\mathrm{#1}}}{#2}}}}
\newcommand{\dvectsub}[2]{\ensuremath{\mathrm{d}\vectsub{#1}{#2}}}
\newcommand{\Dvectsub}[2]{\ensuremath{\Delta\vectsub{#1}{#2}}}
\newcommand{\compdvectsub}[3]{\ensuremath{\mathrm{d}\compvectsub{#1}{#2}{#3}}}
\newcommand{\compDvectsub}[3]{\ensuremath{\Delta\compvectsub{#1}{#2}{#3}}}
\newcommand{\scompsdvectsub}[2]{\ensuremath{\lv
  \compdvectsub{#1}{x}{#2},
  \compdvectsub{#1}{y}{#2},
  \compdvectsub{#1}{z}{#2}\rv}}
\newcommand{\scompsDvectsub}[2]{\ensuremath{\lv
  \compDvectsub{#1}{x}{#2},
  \compDvectsub{#1}{y}{#2},
  \compDvectsub{#1}{z}{#2}\rv}}
\newcommand{\dermagvectsub}[3]{\ensuremath{\dbyd{\magvectsub{#1}{#2}}{#3}}}
\newcommand{\Dermagvectsub}[3]{\ensuremath{\DbyD{\magvectsub{#1}{#2}}{#3}}}
\newcommand{\dervectsub}[3]{\ensuremath{\dbyd{\vectsub{#1}{#2}}{#3}}}
\newcommand{\Dervectsub}[3]{\ensuremath{\DbyD{\vectsub{#1}{#2}}{#3}}}
```

```
\ifthenelse{\boolean{@optdoubleabsbars}}
  {\newcommand{\magdervectsub}[3]{\ensuremath{\magof{\dervectsub{#1}{#2}{#3}}}}
   \newcommand{\magDervectsub}[3]{\ensuremath{\magof{\Dervectsub{#1}{#2}{#3}}}}}
  {\newcommand{\magdervectsub}[3]{\ensuremath{\abs{\dervectsub{#1}{#2}{#3}}}}
   \newcommand{\magDervectsub}[3]{\ensuremath{\abs{\Dervectsub{#1}{#2}{#3}}}}}
\newcommand{\compdervectsub}[4]{\ensuremath{\dbyd{\compvectsub{#1}{#2}{#3}}{#4}}}
\newcommand{\compDervectsub}[4]{\ensuremath{\DbyD{\compvectsub{#1}{#2}{#3}}{#4}}}
\newcommand{\scompsdervectsub}[3]{\ensuremath{\lv
  \compdervectsub{#1}{x}{#2}{#3},
  \compdervectsub{#1}{y}{#2}{#3},
  \compdervectsub{#1}{z}{#2}{#3}\rv}}
\newcommand{\scompsDervectsub}[3]{\ensuremath{\lv
  \compDervectsub{#1}{x}{#2}{#3},
  \compDervectsub{#1}{y}{#2}{#3},
  \compDervectsub{#1}{z}{#2}{#3}\rv}}
\newcommand{\comppossub}[2]{\ensuremath{\ssub{#1}{#2}}}
\newcommand{\scompspossub}[1]{\ensuremath{\lv
  \comppossub{x}{#1},
  \comppossub{y}{#1},
  \comppossub{z}{#1}\rv}}
\newcommand{\compdpossub}[2]{\ensuremath{\mathrm{d}\comppossub{#1}{#2}}}
\newcommand{\compDpossub}[2]{\ensuremath{\Delta\comppossub{#1}{#2}}}
\newcommand{\scompsdpossub}[1]{\ensuremath{\lv
  \compdpossub{x}{#1},
  \compdpossub{y}{#1},
  \compdpossub{z}{#1}\rv}}
\newcommand{\scompsDpossub}[1]{\ensuremath{\lv
  \compDpossub{x}{#1},
  \compDpossub{y}{#1},
  \compDpossub{z}{#1}\rv}}
\newcommand{\compderpossub}[3]{\ensuremath{\dbyd{\comppossub{#1}{#2}}{#3}}}
\newcommand{\compDerpossub}[3]{\ensuremath{\DbyD{\comppossub{#1}{#2}}{#3}}}
\newcommand{\scompsderpossub}[2]{\ensuremath{\lv
  \compderpossub{x}{#1}{#2},
  \compderpossub{y}{#1}{#2},
  \compderpossub{z}{#1}{#2}\rv}}
\newcommand{\scompsDerpossub}[2]{\ensuremath{\lv
  \compDerpossub{x}{#1}{#2},
  \compDerpossub{y}{#1}{#2},
  \compDerpossub{z}{#1}{#2}\rv}}
\newcommand{\relpos}[1]{\ensuremath{\vectsub{r}{#1}}}
\newcommand{\relvel}[1]{\ensuremath{\vectsub{v}{#1}}}
\newcommand{\relmom}[1]{\ensuremath{\vectsub{p}{#1}}}
\newcommand{\relfor}[1]{\ensuremath{\vectsub{F}{#1}}}
\newcommand{\vectdotvect}[2]{\ensuremath{{#1}\bullet{#2}}}
\newcommand{\vectdotsvect}[2]{\ensuremath{\scompsvect{#1}\bullet\scompsvect{#2}}}
\newcommand{\vectdotevect}[2]{\ensuremath{
  \compvect{#1}{x}\compvect{#2}{x}+
  \compvect{#1}{y}\compvect{#2}{y}+
  \compvect{#1}{z}\compvect{#2}{z}}}
```

```
\newcommand{\vectdotspos}[1]{\ensuremath{\scompsvect{#1}\bullet\scompspos}}
\newcommand{\vectdotepos}[1]{\ensuremath{
  \compvect{#1}{x}\comppos{x}+
  \compvect{#1}{y}\comppos{y}+
  \compvect{#1}{z}\comppos{z}}}
\newcommand{\vectdotsdvect}[2]{\ensuremath{\scompsvect{#1}\bullet\scompsdvect{#2}}}
\newcommand{\vectdotsDvect}[2]{\ensuremath{\scompsvect{#1}\bullet\scompsDvect{#2}}}
\newcommand{\vectdotedvect}[2]{\ensuremath{
  \compvect{#1}{x}\compdvect{#2}{x}+
  \compvect{#1}{y}\compdvect{#2}{y}+
  \compvect{#1}{z}\compdvect{#2}{z}}}
\newcommand{\vectdoteDvect}[2]{\ensuremath{
  \compvect{#1}{x}\compDvect{#2}{x}+
  \compvect{#1}{y}\compDvect{#2}{y}+
  \compvect{#1}{z}\compDvect{#2}{z}}}
\newcommand{\vectdotsdpos}[1]{\ensuremath{\scompsvect{#1}\bullet\scompsdpos}}
\newcommand{\vectdotsDpos}[1]{\ensuremath{\scompsvect{#1}\bullet\scompsDpos}}
\newcommand{\vectdotedpos}[1]{\ensuremath{
  \compvect{#1}{x}\compdpos{x}+
  \compvect{#1}{y}\compdpos{y}+
  \compvect{#1}{z}\compdpos{z}}}
\newcommand{\vectdoteDpos}[1]{\ensuremath{
  \compvect{#1}{x}\compDpos{x}+
  \compvect{#1}{y}\compDpos{y}+
  \compvect{#1}{z}\compDpos{z}}}
\newcommand{\vectsubdotsvectsub}[4]{\ensuremath{
  \scompsvectsub{#1}{#2}\bullet\scompsvectsub{#3}{#4}}}
\newcommand{\vectsubdotevectsub}[4]{\ensuremath{
  \compvectsub{#1}{x}{#2}\compvectsub{#3}{x}{#4}+
  \compvectsub{#1}{y}{#2}\compvectsub{#3}{y}{#4}+
  \compvectsub{#1}{z}{#2}\compvectsub{#3}{z}{#4}}}
\newcommand{\vectsubdotsdvectsub}[4]{\ensuremath{%
  \scompsvectsub{#1}{#2}\bullet\scompsdvectsub{#3}{#4}}}
\newcommand{\vectsubdotsDvectsub}[4]{\ensuremath{%
  \scompsvectsub{#1}{#2}\bullet\scompsDvectsub{#3}{#4}}}
\newcommand{\vectsubdotedvectsub}[4]{\ensuremath{
  \compvectsub{#1}{x}{#2}\compdvectsub{#3}{x}{#4}+
  \compvectsub{#1}{y}{#2}\compdvectsub{#3}{y}{#4}+
  \compvectsub{#1}{z}{#2}\compdvectsub{#3}{z}{#4}}}
\newcommand{\vectsubdoteDvectsub}[4]{\ensuremath{
  \compvectsub{#1}{x}{#2}\compDvectsub{#3}{x}{#4}+
  \compvectsub{#1}{y}{#2}\compDvectsub{#3}{y}{#4}+
  \compvectsub{#1}{z}{#2}\compDvectsub{#3}{z}{#4}}}
\newcommand{\vectsubdotsdvect}[3]{\ensuremath{
  \scompsvectsub{#1}{#2}\bullet\scompsdvect{#3}}}
\newcommand{\vectsubdotsDvect}[3]{\ensuremath{
  \scompsvectsub{#1}{#2}\bullet\scompsDvect{#3}}}
\newcommand{\vectsubdotedvect}[3]{\ensuremath{
  \compvectsub{#1}{x}{#2}\compdvect{x}{#3}+
  \compvectsub{#1}{y}{#2}\compdvect{y}{#3}+
```

```
  \compvectsub{#1}{z}{#2}\compdvect{z}{#3}}}
\newcommand{\vectsubdoteDvect}[3]{\ensuremath{
  \compvectsub{#1}{x}{#2}\compDvect{x}{#3}+
  \compvectsub{#1}{y}{#2}\compDvect{y}{#3}+
  \compvectsub{#1}{z}{#2}\compDvect{z}{#3}}}
\newcommand{\vectsubdotsdpos}[2]{\ensuremath{
  \scompsvectsub{#1}{#2}\bullet\scompsdpos}}
\newcommand{\vectsubdotsDpos}[2]{\ensuremath{
  \scompsvectsub{#1}{#2}\bullet\scompsDpos}}
\newcommand{\vectsubdotedpos}[2]{\ensuremath{
  \compvectsub{#1}{x}{#2}\compdpos{x}+
  \compvectsub{#1}{y}{#2}\compdpos{y}+
  \compvectsub{#1}{z}{#2}\compdpos{z}}}
\newcommand{\vectsubdoteDpos}[2]{\ensuremath{
  \compvectsub{#1}{x}{#2}\compDpos{x}+
  \compvectsub{#1}{y}{#2}\compDpos{y}+
  \compvectsub{#1}{z}{#2}\compDpos{z}}}
\newcommand{\dervectdotsvect}[3]{\ensuremath{
  \scompsdervect{#1}{#2}\bullet\scompsvect{#3}}}
\newcommand{\Dervectdotsvect}[3]{\ensuremath{
  \scompsDervect{#1}{#2}\bullet\scompsvect{#3}}}
\newcommand{\dervectdotevect}[3]{\ensuremath{
  \compdervect{#1}{x}{#2}\compvect{x}{#3}+
  \compdervect{#1}{y}{#2}\compvect{y}{#3}+
  \compdervect{#1}{z}{#2}\compvect{z}{#3}}}
\newcommand{\Dervectdotevect}[3]{\ensuremath{
  \compDervect{#1}{x}{#2}\compvect{x}{#3}+
  \compDervect{#1}{y}{#2}\compvect{y}{#3}+
  \compDervect{#1}{z}{#2}\compvect{z}{#3}}}
\newcommand{\vectdotsdervect}[3]{\ensuremath{
  \scompsvect{#1}\bullet\scompsdervect{#2}{#3}}}
\newcommand{\vectdotsDervect}[3]{\ensuremath{
  \scompsvect{#1}\bullet\scompsDervect{#2}{#3}}}
\newcommand{\vectdotedervect}[3]{\ensuremath{
  \compvect{#1}{x}\compdervect{#2}{x}{#3}+
  \compvect{#1}{y}\compdervect{#2}{y}{#3}+
  \compvect{#1}{z}\compdervect{#2}{z}{#3}}}
\newcommand{\vectdoteDervect}[3]{\ensuremath{
  \compvect{#1}{x}\compDervect{#2}{x}{#3}+
  \compvect{#1}{y}\compDervect{#2}{y}{#3}+
  \compvect{#1}{z}\compDervect{#2}{z}{#3}}}
\newcommand{\dervectdotspos}[2]{\ensuremath{
  \scompsdervect{#1}{#2}\bullet\scompspos}}
\newcommand{\Dervectdotspos}[2]{\ensuremath{
  \scompsDervect{#1}{#2}\bullet\scompspos}}
\newcommand{\dervectdotepos}[2]{\ensuremath{
  \compdervect{#1}{x}{#2}\comppos{x}+
  \compdervect{#1}{y}{#2}\comppos{y}+
  \compdervect{#1}{z}{#2}\comppos{z}}}
\newcommand{\Dervectdotepos}[2]{\ensuremath{
```

```
  \compDervect{#1}{x}{#2}\comppos{x}+
  \compDervect{#1}{y}{#2}\comppos{y}+
  \compDervect{#1}{z}{#2}\comppos{z}}}
\newcommand{\dervectdotsdvect}[3]{\ensuremath{
  \scompsdervect{#1}{#2}\bullet\scompsdvect{#3}}}
\newcommand{\DervectdotsDvect}[3]{\ensuremath{
  \scompsDervect{#1}{#2}\bullet\scompsDvect{#3}}}
\newcommand{\dervectdotedvect}[3]{\ensuremath{
  \compdervect{#1}{x}{#2}\compdvect{#3}{x}+
  \compdervect{#1}{y}{#2}\compdvect{#3}{y}+
  \compdervect{#1}{z}{#2}\compdvect{#3}{z}}}
\newcommand{\DervectdoteDvect}[3]{\ensuremath{
  \compDervect{#1}{x}{#2}\compDvect{#3}{x}+
  \compDervect{#1}{y}{#2}\compDvect{#3}{y}+
  \compDervect{#1}{z}{#2}\compDvect{#3}{z}}}
\newcommand{\dervectdotsdpos}[2]{\ensuremath{
  \scompsdervect{#1}{#2}\bullet\scompsdpos}}
\newcommand{\DervectdotsDpos}[2]{\ensuremath{
  \scompsDervect{#1}{#2}\bullet\scompsDpos}}
\newcommand{\dervectdotedpos}[2]{\ensuremath{
  \compdervect{#1}{x}{#2}\compdpos{x}+
  \compdervect{#1}{y}{#2}\compdpos{y}+
  \compdervect{#1}{z}{#2}\compdpos{z}}}
\newcommand{\DervectdoteDpos}[2]{\ensuremath{
  \compDervect{#1}{x}{#2}\compDpos{x}+
  \compDervect{#1}{y}{#2}\compDpos{y}+
  \compDervect{#1}{z}{#2}\compDpos{z}}}
\newcommand{\vectcrossvect}[2]{\ensuremath{{#1}\times{#2}}}
\newcommand{\ltriplecross}[3]{\ensuremath{({#1}\times{#2})\times{#3}}}
\newcommand{\rtriplecross}[3]{\ensuremath{{#1}\times({#2}\times{#3})}}
\newcommand{\ltriplescalar}[3]{\ensuremath{{#1}\times{#2}\bullet{#3}}}
\newcommand{\rtriplescalar}[3]{\ensuremath{{#1}\bullet{#2}\times{#3}}}
\newcommand{\ezero}{\ensuremath{\msub{\mathbf{e}}{0}}}
\newcommand{\eone}{\ensuremath{\msub{\mathbf{e}}{1}}}
\newcommand{\etwo}{\ensuremath{\msub{\mathbf{e}}{2}}}
\newcommand{\ethree}{\ensuremath{\msub{\mathbf{e}}{3}}}
\newcommand{\efour}{\ensuremath{\msub{\mathbf{e}}{4}}}
\newcommand{\ek}[1]{\ensuremath{\msub{\mathbf{e}}{#1}}}
\newcommand{\e}{\ek}
\newcommand{\uezero}{\ensuremath{\msub{\widehat{\mathbf{e}}}{0}}}
\newcommand{\ueone}{\ensuremath{\msub{\widehat{\mathbf{e}}}{1}}}
\newcommand{\uetwo}{\ensuremath{\msub{\widehat{\mathbf{e}}}{2}}}
\newcommand{\uethree}{\ensuremath{\msub{\widehat{\mathbf{e}}}{3}}}
\newcommand{\uefour}{\ensuremath{\msub{\widehat{\mathbf{e}}}{4}}}
\newcommand{\uek}[1]{\ensuremath{\msub{\widehat{\mathbf{e}}}{#1}}}
\newcommand{\ue}{\uek}
\newcommand{\ezerozero}{\ek{00}}
\newcommand{\ezeroone}{\ek{01}}
\newcommand{\ezerotwo}{\ek{02}}
\newcommand{\ezerothree}{\ek{03}}
```

```
\newcommand{\ezerofour}{\ek{04}}
\newcommand{\eoneone}{\ek{11}}
\newcommand{\eonetwo}{\ek{12}}
\newcommand{\eonethree}{\ek{13}}
\newcommand{\eonefour}{\ek{14}}
\newcommand{\etwoone}{\ek{21}}
\newcommand{\etwotwo}{\ek{22}}
\newcommand{\etwothree}{\ek{23}}
\newcommand{\etwofour}{\ek{24}}
\newcommand{\ethreeone}{\ek{31}}
\newcommand{\ethreetwo}{\ek{32}}
\newcommand{\ethreethree}{\ek{33}}
\newcommand{\ethreefour}{\ek{34}}
\newcommand{\efourone}{\ek{41}}
\newcommand{\efourtwo}{\ek{42}}
\newcommand{\efourthree}{\ek{43}}
\newcommand{\efourfour}{\ek{44}}
\newcommand{\euzero}{\ensuremath{\msup{\mathbf{e}}{0}}}
\newcommand{\euone}{\ensuremath{\msup{\mathbf{e}}{1}}}
\newcommand{\eutwo}{\ensuremath{\msup{\mathbf{e}}{2}}}
\newcommand{\euthree}{\ensuremath{\msup{\mathbf{e}}{3}}}
\newcommand{\eufour}{\ensuremath{\msup{\mathbf{e}}{4}}}
\newcommand{\euk}[1]{\ensuremath{\msup{\mathbf{e}}{#1}}}
\newcommand{\eu}{\euk}
\newcommand{\euzerozero}{\euk{00}}
\newcommand{\euzeroone}{\euk{01}}
\newcommand{\euzerotwo}{\euk{02}}
\newcommand{\euzerothree}{\euk{03}}
\newcommand{\euzerofour}{\euk{04}}
\newcommand{\euoneone}{\euk{11}}
\newcommand{\euonetwo}{\euk{12}}
\newcommand{\euonethree}{\euk{13}}
\newcommand{\euonefour}{\euk{14}}
\newcommand{\eutwoone}{\euk{21}}
\newcommand{\eutwotwo}{\euk{22}}
\newcommand{\eutwothree}{\euk{23}}
\newcommand{\eutwofour}{\euk{24}}
\newcommand{\euthreeone}{\euk{31}}
\newcommand{\euthreetwo}{\euk{32}}
\newcommand{\euthreethree}{\euk{33}}
\newcommand{\euthreefour}{\euk{34}}
\newcommand{\eufourone}{\euk{41}}
\newcommand{\eufourtwo}{\euk{42}}
\newcommand{\eufourthree}{\euk{43}}
\newcommand{\eufourfour}{\euk{44}}
\newcommand{\gzero}{\ensuremath{\msub{\mathbf{\gamma}}{0}}}
\newcommand{\gone}{\ensuremath{\msub{\mathbf{\gamma}}{1}}}
\newcommand{\gtwo}{\ensuremath{\msub{\mathbf{\gamma}}{2}}}
\newcommand{\gthree}{\ensuremath{\msub{\mathbf{\gamma}}{3}}}
\newcommand{\gfour}{\ensuremath{\msub{\mathbf{\gamma}}{4}}}
```

```
\newcommand{\gk}[1]{\ensuremath{\msub{\mathbf{\gamma}}{#1}}}
\newcommand{\g}{\gk}
\newcommand{\gzerozero}{\gk{00}}
\newcommand{\gzeroone}{\gk{01}}
\newcommand{\gzerotwo}{\gk{02}}
\newcommand{\gzerothree}{\gk{03}}
\newcommand{\gzerofour}{\gk{04}}
\newcommand{\goneone}{\gk{11}}
\newcommand{\gonetwo}{\gk{12}}
\newcommand{\gonethree}{\gk{13}}
\newcommand{\gonefour}{\gk{14}}
\newcommand{\gtwoone}{\gk{21}}
\newcommand{\gtwotwo}{\gk{22}}
\newcommand{\gtwothree}{\gk{23}}
\newcommand{\gtwofour}{\gk{24}}
\newcommand{\gthreeone}{\gk{31}}
\newcommand{\gthreetwo}{\gk{32}}
\newcommand{\gthreethree}{\gk{33}}
\newcommand{\gthreefour}{\gk{34}}
\newcommand{\gfourone}{\gk{41}}
\newcommand{\gfourtwo}{\gk{42}}
\newcommand{\gfourthree}{\gk{43}}
\newcommand{\gfourfour}{\gk{44}}
\newcommand{\guzero}{\ensuremath{\msup{\mathbf{\gamma}}{0}}}
\newcommand{\guone}{\ensuremath{\msup{\mathbf{\gamma}}{1}}}
\newcommand{\gutwo}{\ensuremath{\msup{\mathbf{\gamma}}{2}}}
\newcommand{\guthree}{\ensuremath{\msup{\mathbf{\gamma}}{3}}}
\newcommand{\gufour}{\ensuremath{\msup{\mathbf{\gamma}}{4}}}
\newcommand{\guk}[1]{\ensuremath{\msup{\mathbf{\gamma}}{#1}}}
\newcommand{\gu}{\guk}
\newcommand{\guzerozero}{\guk{00}}
\newcommand{\guzeroone}{\guk{01}}
\newcommand{\guzerotwo}{\guk{02}}
\newcommand{\guzerothree}{\guk{03}}
\newcommand{\guzerofour}{\guk{04}}
\newcommand{\guoneone}{\guk{11}}
\newcommand{\guonetwo}{\guk{12}}
\newcommand{\guonethree}{\guk{13}}
\newcommand{\guonefour}{\guk{14}}
\newcommand{\gutwoone}{\guk{21}}
\newcommand{\gutwotwo}{\guk{22}}
\newcommand{\gutwothree}{\guk{23}}
\newcommand{\gutwofour}{\guk{24}}
\newcommand{\guthreeone}{\guk{31}}
\newcommand{\guthreetwo}{\guk{32}}
\newcommand{\guthreethree}{\guk{33}}
\newcommand{\guthreefour}{\guk{34}}
\newcommand{\gufourone}{\guk{41}}
\newcommand{\gufourtwo}{\guk{42}}
\newcommand{\gufourthree}{\guk{43}}
```

```
\newcommand{\gufourfour}{\guk{44}}
\ExplSyntaxOn % Vectors formated as in M\&I, written in LaTeX3
\NewDocumentCommand{\mivector}{ O{,} m o }%
 {%
   \mi_vector:nn { #1 } { #2 }
   \IfValueT{#3}{\;{#3}}
 }%
\seq_new:N \l__mi_list_seq
\cs_new_protected:Npn \mi_vector:nn #1 #2
{%
  \ensuremath{%
    \seq_set_split:Nnn \l__mi_list_seq { , } { #2 }
    \int_compare:nF { \seq_count:N \l__mi_list_seq = 1 } { \left\langle }
    \seq_use:Nnnn \l__mi_list_seq { #1 } { #1 } { #1 }
    \int_compare:nF { \seq_count:N \l__mi_list_seq = 1 } { \right\rangle }
  }%
}%
\ExplSyntaxOff
\ExplSyntaxOn % Column and row vectors, written in LaTeX3
\seq_new:N \l__vector_arg_seq
\cs_new_protected:Npn \vector_main:nnnn #1 #2 #3 #4
 {%
  \seq_set_split:Nnn \l__vector_arg_seq { #3 } { #4 }
  \begin{#1matrix}
    \seq_use:Nnnn \l__vector_arg_seq { #2 } { #2 } { #2 }
  \end{#1matrix}
 }%
\NewDocumentCommand{\rowvector}{ O{,} m }
 {%
  \ensuremath{
  \vector_main:nnnn { p } { \,\, } { #1 } { #2 }
  }%
 }%
\NewDocumentCommand{\colvector}{ O{,} m }
 {%
  \ensuremath{
  \vector_main:nnnn { p } { \\ } { #1 } { #2 }
  }%
 }%
\ExplSyntaxOff
\newcommandx{\scompscvect}[2][1,usedefault]{%
  \ifthenelse{\equal{#1}{}}%
  {%
    \colvector{\msub{#2}{1},\msub{#2}{2},\msub{#2}{3}}%
  }%
  {%
    \colvector{\msub{#2}{0},\msub{#2}{1},\msub{#2}{2},\msub{#2}{3}}%
  }%
}%
\newcommandx{\scompsrvect}[2][1,usedefault]{%
```

```
  \ifthenelse{\equal{#1}{}}%
  {%
    \rowvector[,]{\msub{#2}{1},\msub{#2}{2},\msub{#2}{3}}%
  }%
  {%
    \rowvector[,]{\msub{#2}{0},\msub{#2}{1},\msub{#2}{2},\msub{#2}{3}}%
  }%
}%
\newphysicsconstant{oofpez}{\ensuremath{\frac{1}{\phantom{_o}4\pi\ssub{\epsilon}{o}}}}
{\scin[8.9876]{9}}{\m\cubed\usk\kg\usk\reciprocalquartic\s\usk\A\reciprocalsquared}
[\m\per\farad][\newton\usk\m\squared\per\coulomb\squared]
\newcommand{\coulombconstant}{\oofpez}
\newphysicsconstant{oofpezcs}{\ensuremath{\frac{1}{\phantom{_o}4\pi\ssub{\epsilon}{o}
c^2\phantom{_o}}}}{\scin{-7}}{\m\usk\kg\usk\s\reciprocalsquared\usk\A\reciprocalsquared}
[\T\usk\m\squared][\N\usk\s\squared\per\C\squared]
\newcommand{\altcoulombconstant}{\oofpezcs}
\newphysicsconstant{vacuumpermittivity}{\ensuremath{\ssub{\epsilon}{o}}}{\scin[8.8542]{-12}}
{\m\reciprocalcubed\usk\reciprocal\kg\usk\s\quarted\usk\A\squared}[\F\per\m]
[\C\squared\per\N\usk\m\squared]
\newphysicsconstant{mzofp}{\ensuremath{\frac{\phantom{_oo}\ssub{\mu}{o}\phantom{_o}}
{4\pi}}}{\scin{-7}}{\m\usk\kg\usk\s\reciprocalsquared\usk\A\reciprocalsquared}
[\henry\per\m][\tesla\usk\m\per\A]
\newcommand{\biotsavartconstant}{\mzofp}
\newphysicsconstant{vacuumpermeability}{\ensuremath{\ssub{\mu}{o}}}{\scin[4\pi]{-7}}
{\m\usk\kg\usk\s\reciprocalsquared\usk\A\reciprocalsquared}[\henry\per\m]
[\T\usk\m\per\A]
\newphysicsconstant{boltzmann}{\ensuremath{\ssub{k}{B}}}{\scin[1.3806]{-23}}
{\m\squared\usk\kg\usk\reciprocalsquare\s\usk\reciprocal\K}[\joule\per\K][\J\per\K]
\newcommand{\boltzmannconstant}{\boltzmann}
\newphysicsconstant{boltzmanninev}{\ensuremath{\ssub{k}{B}}}{\scin[8.6173]{-5}}
{\eV\usk\reciprocal\K}[\eV\per\K][\eV\per\K]
\newphysicsconstant{stefanboltzmann}{\ensuremath{\sigma}}{\scin[5.6704]{-8}}
{\kg\usk\s\reciprocalcubed\usk\K\reciprocalquarted}[\W\per\m\squared\usk\K^4]
[\W\per\m\squared\usk\K\quarted]
\newcommand{\stefanboltzmannconstant}{\stefanboltzmann}
\newphysicsconstant{planck}{\ensuremath{h}}{\scin[6.6261]{-34}}
{\m\squared\usk\kg\usk\reciprocal\s}[\J\usk\s][\J\usk\s]
\newcommand{\planckconstant}{\planck}
\newphysicsconstant{planckinev}{\ensuremath{h}}{\scin[4.1357]{-15}}
{\eV\usk\s}[\eV\usk\s][\eV\usk\s]
\newphysicsconstant{planckbar}{\ensuremath{\hbar}}{\scin[1.0546]{-34}}
{\m\squared\usk\kg\usk\reciprocal\s}[\J\usk\s][\J\usk\s]
\newcommand{\reducedplanckconstant}{\planckbar}
\newphysicsconstant{planckbarinev}{\ensuremath{\hbar}}{\scin[6.5821]{-16}}
{\eV\usk\s}[\eV\usk\s][\eV\usk\s]
\newphysicsconstant{planckc}{\ensuremath{hc}}{\scin[1.9864]{-25}}
{\m\cubed\usk\kg\usk\reciprocalsquare\s}[\J\usk\m][\J\usk\m]
\newcommand{\planckconstanttimesc}{\planckc}
\newphysicsconstant{planckcinev}{\ensuremath{hc}}{\scin[1.9864]{-25}}
{\eV\usk\ensuremath{\mathrm{n}\m}}[\eV\usk\ensuremath{\mathrm{n}\m}]
```

```
[\eV\usk\ensuremath{\mathrm{n}\m}]
\newphysicsconstant{rydberg}{\ensuremath{\msub{R}{\infty}}}{\scin[1.0974]{7}}
{\reciprocal\m}[\reciprocal\m][\reciprocal\m]
\newcommand{\rydbergconstant}{\rydberg}
\newphysicsconstant{bohrradius}{\ensuremath{\msub{a}{0}}}{\scin[5.2918]{-11}}{\m}[\m][\m]
\newphysicsconstant{finestructure}{\ensuremath{\alpha}}{\scin[7.2974]{-3}}{\relax}
\newcommand{\finestructureconstant}{\finestructure}
\newphysicsconstant{avogadro}{\ensuremath{\ssub{N}{A}}}{\scin[6.0221]{23}}
{\reciprocal\mol}[\reciprocal\mol][\reciprocal\mol]
\newcommand{\avogadroconstant}{\avogadro}
\newphysicsconstant{universalgrav}{\ensuremath{G}}{\scin[6.6738]{-11}}
{\m\cubed\usk\reciprocal\kg\usk\s\reciprocalsquared}[\J\usk\m\per\kg\squared]
[\N\usk\m\squared\per\kg\squared]
\newcommand{\universalgravitationalconstant}{\universalgrav}
\newphysicsconstant{surfacegravfield}{\ensuremath{g}}{9.80}{\m\usk\s\reciprocalsquared}
[\N\per\kg][\m\per\s\squared]
\newcommand{\earthssurfacegravitationalfield}{\surfacegravfield}
\newphysicsconstant{clight}{\ensuremath{c}}{\scin[2.9979]{8}}{\m\usk\reciprocal\s}
[\m\per\s][\m\per\s]
\newcommand{\photonconstant}{\clight}
\newphysicsconstant{clightinfeet}{\ensuremath{c}}{0.9836}
{\ensuremath{\mathrm{ft}\usk\reciprocal\mathrm{n}\s}}
[\ensuremath{\mathrm{ft}\per\mathrm{n}\s}][\ensuremath{\mathrm{ft}\per\mathrm{n}\s}]
\newphysicsconstant{Ratom}{\ensuremath{\ssub{r}{atom}}}{\scin{-10}}{\m}[\m][\m]
\newcommand{\radiusofatom}{\Ratom}
\newphysicsconstant{Mproton}{\ensuremath{\ssub{m}{proton}}}{\scin[1.6726]{-27}}
{\kg}[\kg][\kg]
\newcommand{\massofproton}{\Mproton}
\newphysicsconstant{Mneutron}{\ensuremath{\ssub{m}{neutron}}}{\scin[1.6749]{-27}}
{\kg}[\kg][\kg]
\newcommand{\massofneutron}{\Mneutron}
\newphysicsconstant{Mhydrogen}{\ensuremath{\ssub{m}{hydrogen}}}{\scin[1.6737]{-27}}
{\kg}[\kg][\kg]
\newcommand{\massofhydrogen}{\Mhydrogen}
\newphysicsconstant{Melectron}{\ensuremath{\ssub{m}{electron}}}{\scin[9.1094]{-31}}
{\kg}[\kg][\kg]
\newcommand{\massofelectron}{\Melectron}
\newphysicsconstant{echarge}{\ensuremath{e}}{\scin[1.6022]{-19}}{\A\usk\s}[\C][\C]
\newcommand{\elementarycharge}{\echarge}
\newphysicsconstant{Qelectron}{\ensuremath{\ssub{Q}{electron}}}{-\echargevalue}
{\A\usk\s}[\C][\C]
\newphysicsconstant{qelectron}{\ensuremath{\ssub{q}{electron}}}{-\echargevalue}
{\A\usk\s}[\C][\C]
\newcommand{\chargeofelectron}{\Qelectron}
\newphysicsconstant{Qproton}{\ensuremath{\ssub{Q}{proton}}}{+\echargevalue}
{\A\usk\s}[\C][\C]
\newphysicsconstant{qproton}{\ensuremath{\ssub{q}{proton}}}{+\echargevalue}
{\A\usk\s}[\C][\C]
\newcommand{\chargeofproton}{\Qproton}
\newphysicsconstant{MEarth}{\ensuremath{\ssub{M}{Earth}}}{\scin[5.9736]{24}}{\kg}[\kg][\kg]
```

```
\newcommand{\massofEarth}{\MEarth}
\newphysicsconstant{MMoon}{\ensuremath{\ssub{M}{Moon}}}{\scin[7.3459]{22}}{\kg}[\kg][\kg]
\newcommand{\massofMoon}{\MMoon}
\newphysicsconstant{MSun}{\ensuremath{\ssub{M}{Sun}}}{\scin[1.9891]{30}}{\kg}[\kg][\kg]
\newcommand{\massofSun}{\MSun}
\newphysicsconstant{REarth}{\ensuremath{\ssub{R}{Earth}}}{\scin[6.3675]{6}}{\m}[\m][\m]
\newcommand{\radiusofEarth}{\REarth}
\newphysicsconstant{RMoon}{\ensuremath{\ssub{R}{Moon}}}{\scin[1.7375]{6}}{\m}[\m][\m]
\newcommand{\radiusofMoon}{\RMoon}
\newphysicsconstant{RSun}{\ensuremath{\ssub{R}{Sun}}}{\scin[6.9634]{8}}{\m}[\m][\m]
\newcommand{\radiusofSun}{\RSun}
\newphysicsconstant{ESdist}{\magvectsub{r}{ES}}{\scin[1.4960]{11}}{\m}[\m][\m]
\newphysicsconstant{SEdist}{\magvectsub{r}{SE}}{\scin[1.4960]{11}}{\m}[\m][\m]
\newcommand{\EarthSundistance}{\ESdist}
\newcommand{\SunEarthdistance}{\SEdist}
\newphysicsconstant{EMdist}{\magvectsub{r}{EM}}{\scin[3.8440]{8}}{\m}[\m][\m]
\newphysicsconstant{MEdist}{\magvectsub{r}{ME}}{\scin[3.8440]{8}}{\m}[\m][\m]
\newcommand{\EarthMoondistance}{\ESdist}
\newcommand{\MoonEarthdistance}{\SEdist}
\newphysicsconstant{LSun}{\ensuremath{\ssub{L}{Sun}}}{\scin[3.8460]{26}}
  {\m\squared\usk\kg\usk\s\reciprocalcubed}[\W][\J\per\s]
\newphysicsconstant{TSun}{\ensuremath{\ssub{T}{Sun}}}{5778}{\K}[\K][\K]
\newphysicsconstant{MagSun}{\ensuremath{\ssub{M}{Sun}}}{+4.83}{}[][]
\newphysicsconstant{magSun}{\ensuremath{\ssub{m}{Sun}}}{-26.74}{}[][]
\newcommand{\Lstar}[1][\(\star\)]{\ensuremath{\ssub{L}{#1}}}
\newcommand{\Lsolar}{\ensuremath{\Lstar[\(\odot\)]}}
\newcommand{\Tstar}[1][\(\star\)]{\ensuremath{\ssub{T}{#1}}}
\newcommand{\Tsolar}{\ensuremath{\Tstar[\(\odot\)]}}
\newcommand{\Rstar}[1][\(\star\)]{\ensuremath{\ssub{R}{#1}}}
\newcommand{\Rsolar}{\ensuremath{\Rstar[\(\odot\)]}}
\newcommand{\Mstar}[1][\(\star\)]{\ensuremath{\ssub{M}{#1}}}
\newcommand{\Msolar}{\ensuremath{\Mstar[\(\odot\)]}}
\newcommand{\Fstar}[1][\(\star\)]{\ensuremath{\ssub{F}{#1}}}
\newcommand{\fstar}[1][\(\star\)]{\ensuremath{\ssub{f}{#1}}}
\newcommand{\Fsolar}{\ensuremath{\Fstar[\(\odot\)]}}
\newcommand{\fsolar}{\ensuremath{\fstar[\(\odot\)]}}
\newcommand{\Magstar}[1][\(\star\)]{\ensuremath{\ssub{M}{#1}}}
\newcommand{\magstar}[1][\(\star\)]{\ensuremath{\ssub{m}{#1}}}
\newcommand{\Magsolar}{\ensuremath{\Magstar[\(\odot\)]}}
\newcommand{\magsolar}{\ensuremath{\magstar[\(\odot\)]}}
\newcommand{\Dstar}[1][\(\star\)]{\ensuremath{\ssub{D}{#1}}}
\newcommand{\dstar}[1][\(\star\)]{\ensuremath{\ssub{d}{#1}}}
\newcommand{\Dsolar}{\ensuremath{\Dstar[\(\odot\)]}}
\newcommand{\dsolar}{\ensuremath{\dstar[\(\odot\)]}}
\newcommand{\onehalf}{\ensuremath{\frac{1}{2}}\xspace}
\newcommand{\onethird}{\ensuremath{\frac{1}{3}}\xspace}
\newcommand{\onefourth}{\ensuremath{\frac{1}{4}}\xspace}
\newcommand{\onefifth}{\ensuremath{\frac{1}{5}}\xspace}
\newcommand{\onesixth}{\ensuremath{\frac{1}{6}}\xspace}
\newcommand{\oneseventh}{\ensuremath{\frac{1}{7}}\xspace}
```

```
\newcommand{\oneeighth}{\ensuremath{\frac{1}{8}}\xspace}
\newcommand{\oneninth}{\ensuremath{\frac{1}{9}}\xspace}
\newcommand{\onetenth}{\ensuremath{\frac{1}{10}}\xspace}
\newcommand{\twooneths}{\ensuremath{\frac{2}{1}}\xspace}
\newcommand{\twohalves}{\ensuremath{\frac{2}{2}}\xspace}
\newcommand{\twothirds}{\ensuremath{\frac{2}{3}}\xspace}
\newcommand{\twofourths}{\ensuremath{\frac{2}{4}}\xspace}
\newcommand{\twofifths}{\ensuremath{\frac{2}{5}}\xspace}
\newcommand{\twosixths}{\ensuremath{\frac{2}{6}}\xspace}
\newcommand{\twosevenths}{\ensuremath{\frac{2}{7}}\xspace}
\newcommand{\twoeighths}{\ensuremath{\frac{2}{8}}\xspace}
\newcommand{\twoninths}{\ensuremath{\frac{2}{9}}\xspace}
\newcommand{\twotenths}{\ensuremath{\frac{2}{10}}\xspace}
\newcommand{\threeoneths}{\ensuremath{\frac{3}{1}}\xspace}
\newcommand{\threehalves}{\ensuremath{\frac{3}{2}}\xspace}
\newcommand{\threethirds}{\ensuremath{\frac{3}{3}}\xspace}
\newcommand{\threefourths}{\ensuremath{\frac{3}{4}}\xspace}
\newcommand{\threefifths}{\ensuremath{\frac{3}{5}}\xspace}
\newcommand{\threesixths}{\ensuremath{\frac{3}{6}}\xspace}
\newcommand{\threesevenths}{\ensuremath{\frac{3}{7}}\xspace}
\newcommand{\threeeighths}{\ensuremath{\frac{3}{8}}\xspace}
\newcommand{\threeninths}{\ensuremath{\frac{3}{9}}\xspace}
\newcommand{\threetenths}{\ensuremath{\frac{3}{10}}\xspace}
\newcommand{\fouroneths}{\ensuremath{\frac{4}{1}}\xspace}
\newcommand{\fourhalves}{\ensuremath{\frac{4}{2}}\xspace}
\newcommand{\fourthirds}{\ensuremath{\frac{4}{3}}\xspace}
\newcommand{\fourfourths}{\ensuremath{\frac{4}{4}}\xspace}
\newcommand{\fourfifths}{\ensuremath{\frac{4}{5}}\xspace}
\newcommand{\foursixths}{\ensuremath{\frac{4}{6}}\xspace}
\newcommand{\foursevenths}{\ensuremath{\frac{4}{7}}\xspace}
\newcommand{\foureighths}{\ensuremath{\frac{4}{8}}\xspace}
\newcommand{\fourninths}{\ensuremath{\frac{4}{9}}\xspace}
\newcommand{\fourtenths}{\ensuremath{\frac{4}{10}}\xspace}
\newcommand{\dx}[1]{\ensuremath{\,\mathrm{d}{#1}}}
\newcommand{\evalfromto}[3]{\ensuremath{\Bigg.{#1}\Bigg\rvert_{#2}^{#3}}}
\@ifpackageloaded{physymb}{%
  \typeout{mandi: Package physymb detected. Its commands will be used.}
}{%
  \newcommand{\evalat}[2]{\ensuremath{\Bigg.{#1}\Bigg\rvert_{#2}}}
}%
\newcommand{\evaluatedat}[1]{\ensuremath{\Bigg.\Bigg\rvert_{#1}}}
\newcommandx{\integral}[4][1,2,usedefault]{\ensuremath{
  \int_{\ifthenelse{\equal{#1}{}}{}{#4=#1}}^{\ifthenelse{\equal{#2}{}}{}{#4=#2}}}
  {#3}\dx{#4}}
\newcommandx{\Integral}[4][1,2,usedefault]{\ensuremath{
  \bigint_{\ifthenelse{\equal{#1}{}}{}{#4=#1}}^{\ifthenelse{\equal{#2}{}}{}
  {#4=#2}}}{#3}\dx{#4}}
\newcommand{\opensurfintegral}[2]{\ensuremath{
  \int\nolimits_{#1}\vectdotvect{\vect{#2}}{\dirvect{n}}\dx{A}}}
\newcommand{\opensurfIntegral}[2]{\ensuremath{
```

```
  \bigint\nolimits_{\mskip -25.00mu\displaystyle\mathbf{#1}}
  \vectdotvect{\vect{#2}}{\dirvect{n}}
  \dx{A}}}
\newcommand{\closedsurfintegral}[2]{\ensuremath{
  \oint\nolimits_{#1}\vectdotvect{\vect{#2}}{\dirvect{n}}\dx{A}}}
\newcommand{\closedsurfIntegral}[2]{\ensuremath{
  \bigoint\nolimits_{\mskip -25.00mu\displaystyle\mathbf{#1}}\;\;
  \vectdotvect{\vect{#2}}{\dirvect{n}}\dx{A}}}
\newcommand{\openlineintegral}[2]{\ensuremath{
  \int\nolimits_{#1}\vectdotvect{\vect{#2}}{\dirvect{t}}
  \dx{\ell}}}
\newcommand{\openlineIntegral}[2]{\ensuremath{
  \bigint\nolimits_{\mskip -25.00mu\displaystyle\mathbf{#1}}
  \vectdotvect{\vect{#2}}{\dirvect{t}}\dx{\ell}}}
\newcommand{\closedlineintegral}[2]{\ensuremath{
  \oint\nolimits_{#1}\vectdotvect{\vect{#2}}{\dirvect{t}}\dx{\ell}}}
\newcommand{\closedlineIntegral}[2]{\ensuremath{
  \bigoint\nolimits_{\mskip -25.00mu\displaystyle\mathbf {#1}}\;\;
  \vectdotvect{\vect{#2}}{\dirvect{t}}\dx{\ell}}}
\newcommandx{\dbydt}[1][1]{\ensuremath{\frac{\mathrm{d}{#1}}{\mathrm{d}t}}}
\newcommandx{\DbyDt}[1][1]{\ensuremath{\frac{\Delta{#1}}{\Delta t}}}
\newcommandx{\ddbydt}[1][1]{\ensuremath{\frac{\mathrm{d}^{2}{#1}}{\mathrm{d}t^{2}}}}
\newcommandx{\DDbyDt}[1][1]{\ensuremath{\frac{\Delta^{2}{#1}}{\Delta t^{2}}}}
\newcommandx{\pbypt}[1][1]{\ensuremath{\frac{\partial{#1}}{\partial t}}}
\newcommandx{\ppbypt}[1][1]{\ensuremath{\frac{\partial^{2}{#1}}{\partial t^{2}}}}
\newcommand{\dbyd}[2]{\ensuremath{\frac{\mathrm{d}{#1}}{\mathrm{d}{#2}}}}
\newcommand{\DbyD}[2]{\ensuremath{\frac{\Delta{#1}}{\Delta{#2}}}}
\newcommand{\ddbyd}[2]{\ensuremath{\frac{\mathrm{d}^{2}{#1}}{\mathrm{d}{#2}^{2}}}}
\newcommand{\DDbyD}[2]{\ensuremath{\frac{\Delta^{2}{#1}}{\Delta{#2}^{2}}}}
\newcommand{\pbyp}[2]{\ensuremath{\frac{\partial{#1}}{\partial{#2}}}}
\newcommand{\ppbyp}[2]{\ensuremath{\frac{\partial^{2}{#1}}{\partial{#2}^{2}}}}
\newcommand{\seriesfofx}{\ensuremath{%
f(x) \approx f(a) + \frac{f^\prime (a)}{1!}(x-a) + \frac{f^{\prime\prime}(a)}{2!}(x-a)^2
+ \frac{f^{\prime\prime\prime}(a)}{3!}(x-a)^3 + \ldots}\xspace}
\newcommand{\seriesexpx}{\ensuremath{%
e^x \approx 1 + x + \frac{x^2}{2!} + \frac{x^3}{3!} + \ldots}\xspace}
\newcommand{\seriessinx}{\ensuremath{%
\sin x \approx x - \frac{x^3}{3!} + \frac{x^5}{5!} - \ldots}\xspace}
\newcommand{\seriescosx}{\ensuremath{%
\cos x \approx 1 - \frac{x^2}{2!} + \frac{x^4}{4!} - \ldots}\xspace}
\newcommand{\seriestanx}{\ensuremath{%
\tan x \approx x + \frac{x^3}{3} + \frac{2x^5}{15} + \ldots}\xspace}
\newcommand{\seriesatox}{\ensuremath{%
a^x \approx 1 + x \ln{a} + \frac{(x \ln a)^2}{2!} + \frac{(x \ln a)^3}{3!} + \ldots}
\xspace}
\newcommand{\serieslnoneplusx}{\ensuremath{%
\ln(1 \pm x) \approx \pm\; x - \frac{x^2}{2} \pm \frac{x^3}{3} - \frac{x^4}{4} \pm \ldots}
\xspace}
\newcommand{\binomialseries}{\ensuremath{%
(1 + x)^n \approx 1 + nx + \frac{n(n-1)}{2!}x^2 + \ldots}\xspace}
```

```
\@ifpackageloaded{physymb}{%
  \typeout{mandi: Package physymb detected. Its commands will be used.}
}{%
  \newcommand{\gradient}{\ensuremath{\nabla}}
  \newcommand{\divergence}{\ensuremath{\nabla\bullet}}
  \newcommand{\curl}{\ensuremath{\nabla\times}}
  \newcommand{\laplacian}{\ensuremath{\msup{\nabla}{2}}}
  \newcommand{\dalembertian}{\ensuremath{\Box}}
}%
\newcommand{\diracdelta}[1]{\ensuremath{\boldsymbol{\delta}\quant{#1}}}
\@ifpackageloaded{physymb}{%
  \typeout{mandi: Package physymb detected. Its commands will be used.}
}{%
\DeclareMathOperator{\asin}{\sin^{-1}}
\DeclareMathOperator{\acos}{\cos^{-1}}
\DeclareMathOperator{\atan}{\tan^{-1}}
\DeclareMathOperator{\asec}{\sec^{-1}}
\DeclareMathOperator{\acsc}{\csc^{-1}}
\DeclareMathOperator{\acot}{\cot^{-1}}
\DeclareMathOperator{\sech}{sech}
\DeclareMathOperator{\csch}{csch}
\DeclareMathOperator{\asinh}{\sinh^{-1}}
\DeclareMathOperator{\acosh}{\cosh^{-1}}
\DeclareMathOperator{\atanh}{\tanh^{-1}}
\DeclareMathOperator{\asech}{\sech^{-1}}
\DeclareMathOperator{\acsch}{\csch^{-1}}
\DeclareMathOperator{\acoth}{\coth^{-1}}
\DeclareMathOperator{\sgn}{sgn}
}%
\DeclareMathOperator{\dex}{dex}
\newcommand{\logb}[1][\relax]{\ensuremath{\log_{_{#1}}}}
\ifthenelse{\boolean{@optitalicvectors}}
  {\newcommand{\cB}{\ensuremath{c\mskip -5.00mu B}}}
  {\newcommand{\cB}{\ensuremath{\textsf{c}\mskip -3.00mu\mathrm{B}}}}
\newcommand{\newpi}{\ensuremath{\pi\mskip -7.8mu\pi}}
\newcommand{\scripty}[1]{\ensuremath{\mathcalligra{#1}}}
\newcommandx{\flux}[1][1]{\ensuremath{\ssub{\Phi}{#1}}}
\@ifpackageloaded{physymb}{%
  \typeout{mandi: Package physymb detected. Its commands will be used.}
}{%
  \newcommand{\abs}[1]{\ensuremath{\left\lvert{#1}\right\rvert}}
}%
\newcommand{\magof}[1]{\ensuremath{\left\lVert{#1}\right\rVert}}
\newcommand{\dimsof}[1]{\ensuremath{\left[{#1}\right]}}
\newcommand{\unitsof}[1]{\ensuremath{\left[{#1}\right]_{_{u}}}}
\newcommand{\quant}[1]{\ensuremath{\left({#1}\right)}}
\newcommand{\bquant}[1]{\ensuremath{\left[{#1}\right]}}
\newcommand{\changein}[1]{\ensuremath{\delta{#1}}}
\newcommand{\Changein}[1]{\ensuremath{\Delta{#1}}}
\newcommandx{\scin}[3][1,3=\!\!,usedefault]{\ensuremath{%
```

```
  \ifthenelse{\equal{#1}{}}
    {\unit{\msup{10}{#2}}{#3}}
    {\unit{\msup{{#1}\times 10}{#2}}{#3}}}}
\newcommand{\ee}[2]{\texttt{{#1}e{#2}}}
\newcommand{\EE}[2]{\texttt{{#1}E{#2}}}
\newcommand{\dms}[3]{\ensuremath{\indegrees{#1}\inarcminutes{#2}\inarcseconds{#3}}}
\newcommand{\hms}[3]{\ensuremath{{#1}^{\hour}{#2}^{\mathrm{m}}{#3}^{\s}}}
\newcommand{\clockreading}{\hms}
\newcommand{\latitude}[1]{\ensuremath{\unit{#1}{\degree}}}
\newcommand{\latitudeN}[1]{\ensuremath{\unit{#1}{\degree\;\mathrm{N}}}}
\newcommand{\latitudeS}[1]{\ensuremath{\unit{#1}{\degree\;\mathrm{S}}}}
\newcommand{\longitude}[1]{\ensuremath{\unit{#1}{\degree}}}
\newcommand{\longitudeE}[1]{\ensuremath{\unit{#1}{\degree\;\mathrm{E}}}}
\newcommand{\longitudeW}[1]{\ensuremath{\unit{#1}{\degree\;\mathrm{W}}}}
% I have never liked \LaTeX's default subscript positioning, so I have this
% command instead. There may be a better way of doing this.
\newcommand{\ssub}[2]{\ensuremath{{#1}_{_{_{\mbox{\tiny{#2}}}}}}}
% I have never liked \LaTeX's default superscript positioning, so I have this
% command instead. There may be a better way of doing this.
\newcommand{\ssup}[2]{\ensuremath{{#1}^{^{^{\mbox{\tiny{#2}}}}}}}
\newcommand{\ssud}[3]{\ensuremath{{#1}^{^{^{\mbox{\tiny{#2}}}}}_{_{_{\mbox{\tiny{#3}}}}}}}
% I have never liked \LaTeX's default subscript positioning, so I have this
% command instead. There may be a better way of doing this.
\newcommand{\msub}[2]{\ensuremath{#1^{^{\scriptstyle{{}}}}_{_{_{\scriptstyle{#2}}}}}}
% I have never liked \LaTeX's default superscript positioning, so I have this
% command instead. There may be a better way of doing this.
\newcommand{\msup}[2]{\ensuremath{#1^{^{\scriptstyle{#2}}}}}
\newcommand{\msud}[3]{\ensuremath{#1^{^{\scriptstyle{#2}}}_{_{_{\scriptstyle{#3}}}}}}
\newcommand{\levicivita}[1]{\ensuremath{\msub{\varepsilon}{#1}}}
\newcommand{\kronecker}[1]{\ensuremath{\msub{\delta}{#1}}}
\newcommand{\xaxis}{\ensuremath{x\mbox{-axis }}}
\newcommand{\yaxis}{\ensuremath{y\mbox{-axis }}}
\newcommand{\zaxis}{\ensuremath{z\mbox{-axis }}}
\newcommand{\naxis}[1]{\ensuremath{{#1}\mbox{-axis}}}
\newcommand{\xyplane}{\ensuremath{xy\mbox{-plane }}}
\newcommand{\yzplane}{\ensuremath{yz\mbox{-plane }}}
\newcommand{\zxplane}{\ensuremath{zx\mbox{-plane }}}
\newcommand{\yxplane}{\ensuremath{yx\mbox{-plane }}}
\newcommand{\zyplane}{\ensuremath{zy\mbox{-plane }}}
\newcommand{\xzplane}{\ensuremath{xz\mbox{-plane }}}
% Frequently used roots. Prepend |f| for fractional exponents.
\newcommand{\cuberoot}[1]{\ensuremath{\sqrt[3]{#1}}}
\newcommand{\fourthroot}[1]{\ensuremath{\sqrt[4]{#1}}}
\newcommand{\fifthroot}[1]{\ensuremath{\sqrt[5]{#1}}}
\newcommand{\fsqrt}[1]{\ensuremath{\msup{#1}{\onehalf}}}
\newcommand{\fcuberoot}[1]{\ensuremath{\msup{#1}{\onethird}}}
\newcommand{\ffourthroot}[1]{\ensuremath{\msup{#1}{\onefourth}}}
\newcommand{\ffifthroot}[1]{\ensuremath{\msup{#1}{\onefifth}}}
\newcommand{\relgamma}[1]{\ensuremath{
  \frac{1}{\sqrt{1-\msup{\quant{\frac{#1}{c}}}{2}}}}}
```

```
\newcommand{\frelgamma}[1]{\ensuremath{
  \msup{\quant{1-\frac{\msup{{#1}}{2}}{\msup{c}{2}}}}{-\onehalf}}}
\newcommand{\oosqrtomxs}[1]{\ensuremath{\frac{1}{\sqrt{1-\msup{#1}{2}}}}}
\newcommand{\oosqrtomx}[1]{\ensuremath{\frac{1}{\sqrt{1-{#1}}}}}
\newcommand{\ooomx}[1]{\ensuremath{\frac{1}{1-{#1}}}}
\newcommand{\ooopx}[1]{\ensuremath{\frac{1}{1+{#1}}}}
\newcommand{\isequals}{\wordoperator{?}{=}\xspace}
\newcommand{\wordoperator}[2]{\ensuremath{%
  \mathrel{\vcenter{\offinterlineskip
  \halign{\hfil\tiny\upshape##\hfil\cr\noalign{\vskip-.5ex}
    {#1}\cr\noalign{\vskip.5ex}{#2}\cr}}}}}
\newcommand{\definedas}{\wordoperator{defined}{as}\xspace}
\newcommand{\associated}{\wordoperator{associated}{with}\xspace}
\newcommand{\adjustedby}{\wordoperator{adjusted}{by}\xspace}
\newcommand{\earlierthan}{\wordoperator{earlier}{than}\xspace}
\newcommand{\laterthan}{\wordoperator{later}{than}\xspace}
\newcommand{\forevery}{\wordoperator{for}{every}\xspace}
\newcommand{\pwordoperator}[2]{\ensuremath{\left(%
  \mathrel{\vcenter{\offinterlineskip
  \halign{\hfil\tiny\upshape##\hfil\cr\noalign{\vskip-.5ex}
    {#1}\cr\noalign{\vskip.5ex}{#2}\cr}}}\right)}}%
\newcommand{\pdefinedas}{\pwordoperator{defined}{as}\xspace}
\newcommand{\passociated}{\pwordoperator{associated}{with}\xspace}
\newcommand{\padjustedby}{\pwordoperator{adjusted}{by}\xspace}
\newcommand{\pearlierthan}{\pwordoperator{earlier}{than}\xspace}
\newcommand{\platerthan}{\pwordoperator{later}{than}\xspace}
\newcommand{\pforevery}{\pwordoperator{for}{every}\xspace}
\newcommand{\defines}{\ensuremath{\stackrel{\text{\tiny{def}}}{=}}\xspace}
\newcommand{\inframe}[1][\relax]{\ensuremath{\xrightarrow[\text\tiny{\mathcal #1}]{}}\xspace}
\newcommand{\associates}{\ensuremath{\xrightarrow{\text{\tiny{assoc}}}}\xspace}
\newcommand{\becomes}{\ensuremath{\xrightarrow{\text{\tiny{becomes}}}}\xspace}
\newcommand{\rrelatedto}[1]{\ensuremath{\xLongrightarrow{\text{\tiny{#1}}}}}
\newcommand{\lrelatedto}[1]{\ensuremath{\xLongleftarrow[\text{\tiny{#1}}]{}}}
\newcommand{\brelatedto}[2]{\ensuremath{%
  \xLongleftrightarrow[\text{\tiny{#1}}]{\text{\tiny{#2}}}}}
\newcommand{\momentumprinciple}{\ensuremath{
  \vectsub{p}{sys,f}=\vectsub{p}{sys,i}+\Fnetsys\Delta t}}
\newcommand{\LHSmomentumprinciple}{\ensuremath{%
  \vectsub{p}{sys,f}}}
\newcommand{\RHSmomentumprinciple}{\ensuremath{%
  \vectsub{p}{sys,i}+\Fnetsys\Delta t}}
\newcommand{\energyprinciple}{\ensuremath{\ssub{E}{sys,f}=\ssub{E}{sys,i}+
  \ssub{W}{ext}+Q}}
\newcommand{\LHSenergyprinciple}{\ensuremath{\ssub{E}{sys,f}}}
\newcommand{\RHSenergyprinciple}{\ensuremath{\ssub{E}{sys,i}+\ssub{W}{ext}+Q}}
\newcommand{\angularmomentumprinciple}{\ensuremath{\vectsub{L}{sys,A,f}=
  \vectsub{L}{sys,A,i}+\Tnetsys\Delta t}}
\newcommand{\LHSangularmomentumprinciple}{\ensuremath{\vectsub{L}{sys,A,f}}}
\newcommand{\RHSangularmomentumprinciple}{\ensuremath{\vectsub{L}{sys,A,i}+
  \Tnetsys\Delta t}}
```

```
\newcommand{\gravitationalinteraction}{\ensuremath{%
  \universalgravmathsymbol\frac{\msub{M}{1}\msub{M}{2}}{\msup{\magvectsub{r}{12}}{2}}
  \quant{-\dirvectsub{r}{12}}}}
\newcommand{\electricinteraction}{\ensuremath{%
  \oofpezmathsymbol\frac{\msub{Q}{1}\msub{Q}{2}}{\msup{\magvectsub{r}{12}}{2}}
  \dirvectsub{r}{12}}}
\newcommand{\Bfieldofparticle}{\ensuremath{%
  \mzofpmathsymbol\frac{Q\magvect{v}}{\msup{\magvect{r}}{2}}\dirvect{v}\times\dirvect{r}}}
\newcommand{\Efieldofparticle}{\ensuremath{%
  \oofpezmathsymbol\frac{Q}{\msup{\magvect{r}}{2}}\dirvect{r}}}
\newcommand{\Esys}{\ssub{E}{sys}}
\newcommandx{\Us}[1][1]{\ssub{\ssub{U}{s}}{#1}}
\newcommandx{\Ug}[1][1]{\ssub{\ssub{U}{g}}{#1}}
\newcommandx{\Ue}[1][1]{\ssub{\ssub{U}{e}}{#1}}
\newcommandx{\Ktrans}[1][1]{\ssub{\ssub{K}{trans}}{#1}}
\newcommandx{\Krot}[1][1]{\ssub{\ssub{K}{rot}}{#1}}
\newcommandx{\Eparticle}[1][1]{\ssub{\ssub{E}{particle}}{#1}}
\newcommandx{\Einternal}[1][1]{\ssub{\ssub{E}{internal}}{#1}}
\newcommandx{\Erest}[1][1]{\ssub{\ssub{E}{rest}}{#1}}
\newcommandx{\Echem}[1][1]{\ssub{\ssub{E}{chem}}{#1}}
\newcommandx{\Etherm}[1][1]{\ssub{\ssub{E}{therm}}{#1}}
\newcommandx{\Evib}[1][1]{\ssub{\ssub{E}{vib}}{#1}}
\newcommandx{\Ephoton}[1][1]{\ssub{\ssub{E}{photon}}{#1}}
\newcommand{\DEsys}{\Changein\Esys}
\newcommand{\DUs}{\Changein\Us}
\newcommand{\DUg}{\Changein\Ug}
\newcommand{\DUe}{\Changein\Ue}
\newcommand{\DKtrans}{\Changein\Ktrans}
\newcommand{\DKrot}{\Changein\Krot}
\newcommand{\DEparticle}{\Changein\Eparticle}
\newcommand{\DEinternal}{\Changein\Einternal}
\newcommand{\DErest}{\Changein\Erest}
\newcommand{\DEchem}{\Changein\Echem}
\newcommand{\DEtherm}{\Changein\Etherm}
\newcommand{\DEvib}{\Changein\Evib}
\newcommand{\DEphoton}{\Changein\Ephoton}
\newcommand{\Usfinal}{\ssub{\left(\onehalf\ks \msup{s}{2}\right)}{f}}
\newcommand{\Usinitial}{\ssub{\left(\onehalf\ks \msup{s}{2}\right)}{i}}
\newcommand{\Ugfinal}{\ssub{\left(-G\frac{\msub{M}{1}\msub{M}{2}}
  {\magvectsub{r}{12}}\right)}{f}}
\newcommand{\Uginitial}{\ssub{\left(-G\frac{\msub{M}{1}\msub{M}{2}}
  {\magvectsub{r}{12}}\right)}{i}}
\newcommand{\Uefinal}{\ssub{\left(\oofpezmathsymbol\frac{\ssub{Q}{1}\ssub{Q}{2}}
  {\magvectsub{r}{12}}\right)}{f}}
\newcommand{\Ueinitial}{\ssub{\left(\oofpezmathsymbol\frac{\ssub{Q}{1}\ssub{Q}{2}}
  {\magvectsub{r}{12}}\right)}{i}}
\newcommand{\ks}{\ssub{k}{s}}
\newcommand{\Fnet}{\ensuremath{\vectsub{F}{net}}}
\newcommand{\Fnetext}{\ensuremath{\vectsub{F}{net,ext}}}
\newcommand{\Fnetsys}{\ensuremath{\vectsub{F}{net,sys}}}
```

```
\newcommand{\Fsub}[1]{\ensuremath{\vectsub{F}{#1}}}
\newcommand{\Tnet}{\ensuremath{\vectsub{T}{net}}}
\newcommand{\Tnetext}{\ensuremath{\vectsub{T}{net,ext}}}
\newcommand{\Tnetsys}{\ensuremath{\vectsub{T}{net,sys}}}
\newcommand{\Tsub}[1]{\ensuremath{\vectsub{T}{#1}}}
\newcommand{\vpythonline}{\lstinline[language=Python,numbers=left,numberstyle=\tiny,%
  upquote=true,breaklines]}
\lstnewenvironment{vpythonblock}{\lstvpython}{}
\newcommand{\vpythonfile}{\lstinputlisting[language=Python,numbers=left,%
  numberstyle=\tiny,upquote=true,breaklines]}
\newcommandx{\emptyanswer}[2][1=0.80,2=0.1,usedefault]
  {\begin{minipage}{#1\textwidth}\hfill\vspace{#2\textheight}\end{minipage}}
\newenvironmentx{activityanswer}[5][1=white,2=black,3=black,4=0.90,5=0.10,usedefault]{%
  \def\skipper{#5}%
  \def\response@fbox{\fcolorbox{#2}{#1}}%
  \begin{center}%
    \begin{lrbox}{\@tempboxa}%
      \begin{minipage}[c][#5\textheight][c]{#4\textwidth}\color{#3}%
        \vspace{#5\textheight}}{%
        \vspace{\skipper\textheight}%
      \end{minipage}%
    \end{lrbox}%
    \response@fbox{\usebox{\@tempboxa}}%
  \end{center}%
}%
\newenvironmentx{adjactivityanswer}[5][1=white,2=black,3=black,4=0.90,5=0.00,%
  usedefault]{%
  \def\skipper{#5}%
  \def\response@fbox{\fcolorbox{#2}{#1}}%
  \begin{center}%
    \begin{lrbox}{\@tempboxa}%
      \begin{minipage}[c]{#4\textwidth}\color{#3}%
        \vspace{#5\textheight}}{%
        \vspace{\skipper\textheight}%
      \end{minipage}%
    \end{lrbox}%
    \response@fbox{\usebox{\@tempboxa}}%
  \end{center}%
}%
\newcommandx{\emptybox}[6][1=\hfill,2=white,3=black,4=black,5=0.90,6=0.10,usedefault]
  {\begin{center}%
     \fcolorbox{#3}{#2}{%
       \begin{minipage}[c][#6\textheight][c]{#5\textwidth}\color{#4}%
         {#1}%
       \end{minipage}}%
     \vspace{\baselineskip}%
   \end{center}%
}%
\newcommandx{\adjemptybox}[7][1=\hfill,2=white,3=black,4=black,5=0.90,6=,7=0.0,usedefault]
  {\begin{center}%
```

```
      \fcolorbox{#3}{#2}{%
        \begin{minipage}[c]{#5\textwidth}\color{#4}%
          \vspace{#7\textheight}%
            {#1}%
          \vspace{#7\textheight}%
        \end{minipage}}%
      \vspace{\baselineskip}%
    \end{center}%
}%
\newcommandx{\answerbox}[6][1=\hfill,2=white,3=black,4=black,5=0.90,6=0.1,usedefault]
  {\ifthenelse{\equal{#1}{}}%
    {\begin{center}%
       \fcolorbox{#3}{#2}{%
         \emptyanswer[#5][#6]}%
     \vspace{\baselineskip}%
     \end{center}}%
    {\emptybox[#1][#2][#3][#4][#5][#6]}%
}%
\newcommandx{\adjanswerbox}[7][1=\hfill,2=white,3=black,4=black,5=0.90,6=0.1,7=0.0,%
  usedefault]%
  {\ifthenelse{\equal{#1}{}}%
    {\begin{center}%
       \fcolorbox{#3}{#2}{%
         \emptyanswer[#5][#6]}%
     \vspace{\baselineskip}%
     \end{center}}%
    {\adjemptybox[#1][#2][#3][#4][#5][#6][#7]}%
}%
\newcommandx{\smallanswerbox}[6][1=\hfill,2=white,3=black,4=black,5=0.90,6=0.10,%
  usedefault]%
  {\ifthenelse{\equal{#1}{}}%
    {\begin{center}%
       \fcolorbox{#3}{#2}{%
         \emptyanswer[#5][#6]}%
     \vspace{\baselineskip}%
     \end{center}}%
    {\emptybox[#1][#2][#3][#4][#5][#6]}%
}%
\newcommandx{\mediumanswerbox}[6][1=\hfill,2=white,3=black,4=black,5=0.90,6=0.20,%
  usedefault]{%
  \ifthenelse{\equal{#1}{}}%
    {\begin{center}%
       \fcolorbox{#3}{#2}{%
         \emptyanswer[#5][#6]%
       }%
     \vspace{\baselineskip}%
     \end{center}%
    }%
    {\emptybox[#1][#2][#3][#4][#5][#6]%
    }%
```

```
}%
\newcommandx{\largeanswerbox}[6][1=\hfill,2=white,3=black,4=black,5=0.90,6=0.25,%
  usedefault]{%
  \ifthenelse{\equal{#1}{}}%
    {\begin{center}%
       \fcolorbox{#3}{#2}{%
         \emptyanswer[#5][#6]%
       }%
     \vspace{\baselineskip}%
     \end{center}%
    }%
    {\emptybox[#1][#2][#3][#4][#5][#6]%
    }%
}%
\newcommandx{\largeranswerbox}[6][1=\hfill,2=white,3=black,4=black,5=0.90,6=0.33,%
  usedefault]{%
  \ifthenelse{\equal{#1}{}}%
    {\begin{center}%
       \fcolorbox{#3}{#2}{%
         \emptyanswer[#5][#6]%
       }%
     \vspace{\baselineskip}%
     \end{center}%
    }%
    {\emptybox[#1][#2][#3][#4][#5][#6]%
    }%
}%
\newcommandx{\hugeanswerbox}[6][1=\hfill,2=white,3=black,4=black,5=0.90,6=0.50,%
  usedefault]{%
  \ifthenelse{\equal{#1}{}}
    {\begin{center}%
       \fcolorbox{#3}{#2}{%
         \emptyanswer[#5][#6]%
       }%
     \vspace{\baselineskip}%
     \end{center}%
    }%
    {\emptybox[#1][#2][#3][#4][#5][#6]%
    }%
}%
\newcommandx{\hugeranswerbox}[6][1=\hfill,2=white,3=black,4=black,5=0.90,6=0.75,%
  usedefault]{%
  \ifthenelse{\equal{#1}{}}%
    {\begin{center}%
       \fcolorbox{#3}{#2}{%
         \emptyanswer[#5][#6]%
       }%
     \vspace{\baselineskip}%
     \end{center}%
    }%
```

```
    {\emptybox[#1][#2][#3][#4][#5][#6]%
    }%
}%
\newcommandx{\fullpageanswerbox}[6][1=\hfill,2=white,3=black,4=black,5=0.90,6=1.00,%
  usedefault]{%
  \ifthenelse{\equal{#1}{}}%
    {\begin{center}%
       \fcolorbox{#3}{#2}{%
         \emptyanswer[#5][#6]}%
     \vspace{\baselineskip}%
     \end{center}}%
    {\emptybox[#1][#2][#3][#4][#5][#6]}%
}%
\mdfdefinestyle{miinstructornotestyle}{%
    hidealllines=false, skipbelow=\baselineskip, skipabove=\baselineskip,
    leftmargin=40pt, rightmargin=40pt, linewidth=1, roundcorner=10,
    frametitle={INSTRUCTOR NOTE},
    frametitlebackgroundcolor=cyan!60, frametitlerule=true, frametitlerulewidth=1,
    backgroundcolor=cyan!25,
    linecolor=black, fontcolor=black, shadow=true}
\NewEnviron{miinstructornote}{%
  \begin{mdframed}[style=miinstructornotestyle]
    \begin{adjactivityanswer}[cyan!25][cyan!25][black]
      \BODY
    \end{adjactivityanswer}
  \end{mdframed}
}%
\mdfdefinestyle{mistudentnotestyle}{%
    hidealllines=false, skipbelow=\baselineskip, skipabove=\baselineskip,
    leftmargin=40pt, rightmargin=40pt, linewidth=1, roundcorner=10,
    frametitle={STUDENT NOTE},
    frametitlebackgroundcolor=cyan!60, frametitlerule=true, frametitlerulewidth=1,
    backgroundcolor=cyan!25,
    linecolor=black, fontcolor=black, shadow=true}
\NewEnviron{mistudentnote}{%
  \begin{mdframed}[style=mistudentnotestyle]
    \begin{adjactivityanswer}[cyan!25][cyan!25][black]
      \BODY
    \end{adjactivityanswer}
  \end{mdframed}
}%
\mdfdefinestyle{miderivationstyle}{%
    hidealllines=false, skipbelow=\baselineskip, skipabove=\baselineskip,
    leftmargin=0pt, rightmargin=0pt, linewidth=1, roundcorner=10,
    frametitle={DERIVATION},
    frametitlebackgroundcolor=orange!60, frametitlerule=true, frametitlerulewidth=1,
    backgroundcolor=orange!25,
    linecolor=black, fontcolor=black, shadow=true}
\NewEnviron{miderivation}{%
  \begin{mdframed}[style=miderivationstyle]
```

```
  \setcounter{equation}{0}
    \begin{align*}
      \BODY
    \end{align*}
  \end{mdframed}
}%
\mdfdefinestyle{bwinstructornotestyle}{%
    hidealllines=false, skipbelow=\baselineskip, skipabove=\baselineskip,
    leftmargin=40pt, rightmargin=40pt, linewidth=1, roundcorner=10,
    frametitle={INSTRUCTOR NOTE},
    frametitlebackgroundcolor=gray!50, frametitlerule=true, frametitlerulewidth=1,
    backgroundcolor=gray!20,
    linecolor=black, fontcolor=black, shadow=true}
\NewEnviron{bwinstructornote}{%
  \begin{mdframed}[style=bwinstructornotestyle]
    \begin{adjactivityanswer}[gray!20][gray!20][black]
      \BODY
    \end{adjactivityanswer}
  \end{mdframed}
}%
\mdfdefinestyle{bwstudentnotestyle}{%
    hidealllines=false, skipbelow=\baselineskip, skipabove=\baselineskip,
    leftmargin=40pt, rightmargin=40pt, linewidth=1, roundcorner=10,
    frametitle={STUDENT NOTE},
    frametitlebackgroundcolor=gray!50, frametitlerule=true, frametitlerulewidth=1,
    backgroundcolor=gray!20,
    linecolor=black, fontcolor=black, shadow=true}
\NewEnviron{bwstudentnote}{%
  \begin{mdframed}[style=bwstudentnotestyle]
    \begin{adjactivityanswer}[gray!20][gray!20][black]
      \BODY
    \end{adjactivityanswer}
  \end{mdframed}
}%
\mdfdefinestyle{bwderivationstyle}{%
    hidealllines=false, skipbelow=\baselineskip, skipabove=\baselineskip,
    leftmargin=0pt, rightmargin=0pt, linewidth=1, roundcorner=10,
    frametitle={DERIVATION},
    frametitlebackgroundcolor=gray!50, frametitlerule=true, frametitlerulewidth=1,
    backgroundcolor=gray!20,
    linecolor=black, fontcolor=black, shadow=true}
\NewEnviron{bwderivation}{%
  \begin{mdframed}[style=bwderivationstyle]
  \setcounter{equation}{0}
    \begin{align*}
      \BODY
    \end{align*}
  \end{mdframed}
}%
\newcommand{\checkpoint}{%
```

```
  \vspace{1cm}\begin{center}|--------- CHECKPOINT ---------|\end{center}}%
\newcommand{\image}[2]{%
  \begin{figure}[h!]
    \begin{center}%
      \includegraphics[scale=1]{#1}%
      \caption{#2}%
      \label{#1}%
    \end{center}%
  \end{figure}}
\newcommand{\sneakyone}[1]{\ensuremath{\cancelto{1}{\frac{#1}{#1}}}}
% undocumented diagnostic command
\newcommand{\chkquantity}[1]{%
  \begin{center}
    \begin{tabular}{C{3cm} C{3cm} C{3cm} C{3cm}}
      name    & baseunit & drvdunit & tradunit \tabularnewline
      \cs{#1} & \csname #1onlybaseunit\endcsname & \csname #1onlydrvdunit\endcsname &
        \csname #1onlytradunit\endcsname
    \end{tabular}
  \end{center}
}%
% undocumented diagnostic command
\newcommand{\chkconstant}[1]{%
  \begin{center}
    \begin{tabular}{C{3cm} C{1cm} C{2cm} C{3cm} C{3cm} C{3cm}}
      name    & symbol & value & baseunit & drvdunit & tradunit \tabularnewline
      \cs{#1} & \csname #1mathsymbol\endcsname & \csname #1value\endcsname &
        \csname #1onlybaseunit\endcsname & \csname #1onlydrvdunit\endcsname &
        \csname #1onlytradunit\endcsname
    \end{tabular}
  \end{center}
}%
% new |\vect| that allows for subscripts
% #1 = kernel #2 = subscript
\newcommandx{\vecto}[2][2,usedefault]{\ensuremath{%
  \ifthenelse{\equal{#2}{}}%
    {\vec{#1}}%
    {\ssub{\vec{#1}}{#2}}}}%
% new |\compvect| that allows for subscripts
% #1 = kernel #2 = component #3 = subscript
\newcommandx{\compvecto}[3][3,usedefault]{\ensuremath{%
  \ifthenelse{\equal{#3}{}}%
    {\ssub{#1}{\(#2\)}}%
    {\ssub{#1}{\(#2\),#3}}}}%
% new |\scompsvect| that allows for subscripts
% #1 = kernel #2 = subscript
\newcommandx{\scompsvecto}[2][2,usedefault]{\ensuremath{%
  \ifthenelse{\equal{#2}{}}%
    {\lv\compvecto{#1}{x},\compvecto{#1}{y},\compvecto{#1}{z}\rv}%
    {\lv\compvecto{#1}{x}[#2],\compvecto{#1}{y}[#2],\compvecto{#1}{z}[#2]\rv}}}%
% new |\comppos| that allows for subscripts
```

```
\newcommandx{\compposo}[2][2,usedefault]{\ensuremath{%
% #1 = component #2 = subscript
  \ifthenelse{\equal{#1}{}}%
    {#1}%
    {\ssub{#1}{#2}}}}%
% new |\scompspos| that allows for subscripts
% #1 = subscript
\newcommandx{\scompsposo}[1][1,usedefault]{\ensuremath{%
  \ifthenelse{\equal{#1}{}}%
    {\lv\compposo{x},\compposo{y},\compposo{z}\rv}%
    {\lv\compposo{x}[#1],\compposo{y}[#1],\compposo{z}[#1]\rv}}}%
```

7 Acknowledgements

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8 Index

Page numbers refer to page where the corresponding entry is described. Not every command defined in the package is indexed. There may be commands similar to indexed commands described in relevant parts of the documentation.

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