The mandi package

Paul J. Heafner
heafnerj@gmail.com

Version 2.0.0 dated 2012/12/31

Contents

Change History

Possible Future Enhancements

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, which causes confusion, 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 the `mandi` package, simply put the line

`\usepackage{mandi}`

in your document's preamble to load `mandi` with its default options. To use the package's available options, write

`\usepackage`**`[options]`**`{mandi}`

There are five available options, with one option being based on the absence of two of the others.

- **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.

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
```

but it is more logical and more readable to use

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

given that they produce the same output. The second way is what `mandi` lets you do.

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

The second way is more readable if you come back to the document, perhaps having not looked at the source code 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}}.
```

produces

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

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
```

which gives

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

with 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.

To illustrate, `(\oofpezmathsymbol)` gives $(\frac{1}{4\pi\epsilon_\circ})$ but `\((\oofpezmathsymbol)\)` gives $\left(\frac{1}{4\pi\epsilon_\circ}\right)$.

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`

metre or SI unit of spatial displacement (length)

`\m`

m

`\kg`

kilogram or SI unit of mass

`\kg`

kg

`\s`

second or SI unit of temporal displacement (duration)

`\s`

s

`\A`

ampere or SI unit of electric current

`\A`

A

\K

kelvin or SI unit of thermodynamic temperature

\K

K

\mol

mole or SI unit of amount

\mol

mol

\cd

candela or SI unit of luminous intensity

\cd

cd

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, specifically $\mathrm{m} \cdot \mathrm{kg} \cdot \mathrm{s}^{-2}$. 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`

define a physics quantity

```
\newphysicsquantity\marg{foobar}\marg{\baseunits}\oarg{\drvdunits}
  \oarg{\tradunits}
```

Using this command causes several things to happen.

- A command `\yournewquantity{`⟨*magnitude*⟩`}`, where `foobar` is the first argument passed to `\newphysicsquantity`, is created that takes one mandatory argument, a numerical magnitude. Subsequent use of your defined scalar quantity can be invoked by typing `\yournewquantity{`⟨*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 `\yournewquantitybaseunit{`⟨*magnitude*⟩`}` is created that expresses the quantity and its units in *baseunits* form.
- A command `\yournewquantitydrvdunit{`⟨*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 `\yournewquantitytradunit{`⟨*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 `\yournewquantityonlybaseunit{`⟨*magnitude*⟩`}` is created that expresses **only** the quantity's units in *baseunits* form.
- A command `\yournewquantityonlydrvdunit{`⟨*magnitude*⟩`}` is created that expresses **only** the quantity's units in *drvdunits* form.
- A command `\yournewquantityonlytradunit{`⟨*magnitude*⟩`}` is created that expresses **only** the quantity's units in *tradunits* form.
- A command `\yournewquantityvalue{`⟨*magnitude*⟩`}` is created that expresses **only** the quantity's numerical value.

The following command defines the quantity `\displacement` and its associated commands containing its units.

```
\newphysicsquantity{displacement}{\m}[\m][\m]
```

You would then invoke this quantity with `\displacement{3}` to get 3 m in a calculation.

5.3.1 Defining Vector Quantities

Vector quantities are defined exactly like other quantities, except a formatted vector is used when invoking the value of that quantity. The following command defines a vector `\displacementvector` and its associated commands containing its units.

```
\newphysicsquantity{displacementvector}{\m}[\m][\m]
```

You would then invoke this quantity with `\displacementvector{\mivector{2,3,-5}}` to get $\langle 2, 3, -5 \rangle$ m in a calculation.

5.4 First Semester Physics

The first semester of *Matter & Interactions* 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{3.14}`	3.14 m
`\mass{2.81}`	2.81 kg
`\duration{4.32}`	4.32 s
`\current{5.19}`	5.19 A
`\temperature{273}`	273 K
`\amount{2.87}`	2.87 mol
`\luminous{5.64}`	5.64 cd

Okay, so much for the base quantities. While we're at it, let's also go ahead and define plane angle, solid angle, and a few non-SI units of angular measure, energy, and distance.

`\planeangle{2.88}`	2.88 rad
`\solidangle{4\pi}`	4π sr
`\indegrees{30.1}`	30.1°
`\inarcminutes{30.1}`	$30.1'$
`\inarcseconds{30.1}`	$30.1''$
`\ineV{10.2}`	10.2 eV
`\inAU{5.2}`	5.2 AU

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. An optional third argument specifies a unit, but that is not needed in the following examples.

`\velocityc{0.24}`	$0.24c$
`\velocity{2.99}`	2.99 m/s
`\gamman{4.32}`	4.32
`\momentum{\scin[2.44]{4}}`	2.44×10^{4} kg · m/s
`\acceleration{9.81}`	9.81 m/s^2
`\impulse{3.56}`	3.56 kg · m/s
`\force{2.84}`	2.84 N
`\springstiffness{6.92}`	6.92 N/m
`\springstretch{0.212}`	0.212 m
`\area{0.125}`	0.125 m^2
`\volume{5.33}`	5.33 m^3
`\linearmassdensity{2.33}`	2.33 kg/m
`\areamassdensity{3.60}`	3.60 kg/m^2
`\volumemassdensity{27.4}`	27.4 kg/m^3
`\youngsmodulus{\scin[2.12]{9}}`	2.12×10^{9} Pa
`\work{4.04}`	4.04 N · m
`\energy{4.40}`	4.40 N · m
`\power{100.2}`	100.2 J/s
`\angularvelocity{3.02}`	3.02 rad/s
`\angularacceleration{5.32}`	5.32 rad/s^2
`\angularmomentum{6.81}`	6.81 kg · m^2/s
`\momentofinertia{4.59}`	4.59 kg · m^2
`\torque{3.40}`	3.40 N · m
`\entropy{5.95}`	5.95 J/K
`\wavelength{\scin[4.00]{-7}}`	4.00×10^{-7} m
`\wavenumber{\scin[2.50]{6}}`	2.50×10^{6} /m
`\frequency{\scin[7.50]{14}}`	7.50×10^{14} Hz
`\angularfrequency{\scin[4.70]{15}}`	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{\scin[2]{-9}}`	2×10^{-9} C
`\permittivity{\scin[9]{-12}}`	9×10^{-12} C^2/N$\cdot$m^2
`\electricfield{\scin[2]{5}}`	2×10^{5} N/C
`\electricdipolemom{\scin[3]{-22}}`	3×10^{-22} C$\cdot$m
`\permeability{\scin[4\pi]{-7}}`	$4\pi \times 10^{-7}$ T$\cdot$m/A
`\magneticfield{1.25}`	1.25 N/C$\cdot$ (m/s)
`\cmagneticfield{1.25}`	1.25 N/C

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	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.

`\hereusebaseunit` `\hereusedrvdunit` `\hereusetradunit`

A second way is to use the commands `\hereusebaseunit{}`, `\hereusedrvdunit{}`, or `\hereusetradunit{}` with the quantity as the argument.

`\hereusebaseunit{\momentum{3}}`	$3\ \mathrm{m \cdot kg \cdot s^{-1}}$
`\hereusedrvdunit{\momentum{3}}`	$3\ \mathrm{N \cdot s}$
`\hereusetradunit{\momentum{3}}`	$3\ \mathrm{kg \cdot m/s}$

`usebaseunit` `usedrvdunit` `usetradunit`

A third way is to use the `usebaseunit`, `usedrvdunit`, `usetradunit` environments.

```
\begin{usebaseunit}
  \momentum{3}          3 m·kg·s^-1
\end{usebaseunit}
\begin{usedrvdunit}
  \momentum{3}          3 N·s
\end{usedrvdunit}
\begin{usetradunit}
  \momentum{3}          3 kg·m/s
\end{usetradunit}
```

`\perpusebaseunit` `\perpusedrvdunit` `\perpusetradunit`

A fourth way is to use the global switches `\perpusebaseunit`, `\perpusedrvdunit`, and `\perpusetradunit` (think *perpetually use...*). **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.**

5.7 Expressions with Vectors

5.7.1 Basic Vectors

\vect

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

```
\vect{p}
```

$\vec{p}$

\magvect

symbol for a vector quantity's magnitude
\magvect{⟨*kernel*⟩}

```
\magvect{p}
```

$|\vec{p}|$

\dirvect

symbol for a vector quantity's direction
\dirvect{⟨*kernel*⟩}

```
\dirvect{p}
```

$\widehat{p}$

\ncompszerovect

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

```
\ncompszerovect
```

$\langle 0, 0, 0 \rangle$

\symvect

symbol for vector with expressions as components
Deprecated. Use \mivector instead.
\symvect{⟨*listofcomps*⟩}

```
\symvect{\magvect{E}\cos\theta,\magvect{E}\sin\theta,0}
```

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

\ncompsvect

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

```
\ncompsvect{3,4,6}[\m\per\s]
```

$\langle 3, 4, 6 \rangle$ m/s

\magvectncomps

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

```
\magvectncomps{3.12,4.04,6.73}[\m\per\s]
```

$$\sqrt{(3.12 \text{ m/s})^2 + (4.04 \text{ m/s})^2 + (6.73 \text{ m/s})^2}$$

\scompsvect

symbolic components of a vector
\scompsvect{⟨*kernel*⟩}

```
\scompsvect{E}
```

$$\left\langle \mathrm{E}_x, \mathrm{E}_y, \mathrm{E}_z \right\rangle$$

\compvect

symbolic component of a vector
\compvect{⟨*kernel*⟩}{⟨*comp*⟩}

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

E_y

\magvectscomps

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

```
\magvectscomps{B}
```

$$\sqrt{\mathrm{B}_{x}^{2}+\mathrm{B}_{y}^{2}+\mathrm{B}_{z}^{2}}$$

5.7.2 Position Vectors

\scompspos

symbolic components of a position vector
\scompspos

```
\scompspos
```

$\langle x, y, z \rangle$

\comppos

one component of a position vector
\comppos{⟨*comp*⟩}

```
\comppos{y}
```

y

5.7.3 Differentials and Derivatives of Vectors

`\dvect`
`\Dvect`

symbol for the differential of a vector
`\dvect{`⟨*kernel*⟩`}` or `\Dvect{`⟨*kernel*⟩`}`

```
\dvect{E} or \Dvect{E}
```

$\mathrm{d}\vec{\mathrm{E}}$ or $\Delta\vec{\mathrm{E}}$

`\dirdvect`
`\dirDvect`

symbol for the direction of the differential of a vector
`\dirdvect{`⟨*kernel*⟩`}` or `\dirDvect{`⟨*kernel*⟩`}`

```
\dirdvect{E} or \dirDvect{E}
```

$\widehat{\mathrm{d}\vec{\mathrm{E}}}$ or $\widehat{\Delta\vec{\mathrm{E}}}$

`\ddirvect`
`\Ddirvect`

symbol for the differential of a vector's direction
`\ddirvect{`⟨*kernel*⟩`}` or `\Ddirvect{`⟨*kernel*⟩`}`

```
\ddirvect{E} or \Ddirvect{E}
```

$\mathrm{d}\widehat{\mathrm{E}}$ or $\Delta\widehat{\mathrm{E}}$

`\magdvect`
`\magDvect`

magnitude of the differential of a vector
`\magdvect{`⟨*kernel*⟩`}` or `\magDvect{`⟨*kernel*⟩`}`

```
\magdvect{E} or \magDvect{E}
```

$\left|\mathrm{d}\vec{\mathrm{E}}\right|$ or $\left|\Delta\vec{\mathrm{E}}\right|$

`\dmagvect`
`\Dmagvect`

differential of the magnitude of a vector
`\dmagvect{`⟨*kernel*⟩`}` or `\Dmagvect{`⟨*kernel*⟩`}`

```
\dmagvect{E} or \Dmagvect{E}
```

$\mathrm{d}\left|\vec{\mathrm{E}}\right|$ or $\Delta\left|\vec{\mathrm{E}}\right|$

\scompsdvect
\scompsDvect

symbolic components of the differential of a vector
\scompsdvect{⟨*kernel*⟩} or \scompsDvect{⟨*kernel*⟩}

```
\scompsdvect{E} or \scompsDvect{E}
```

$\left\langle \mathrm{dE}_x, \mathrm{dE}_y, \mathrm{dE}_z \right\rangle$ or $\left\langle \Delta\mathrm{E}_x, \Delta\mathrm{E}_y, \Delta\mathrm{E}_z \right\rangle$

\compdvect
\compDvect

one symbolic component of the differential of a vector
\compdvect{⟨*kernel*⟩}{⟨*comp*⟩} or \compDvect{⟨*kernel*⟩} {⟨*comp*⟩}

```
\compdvect{E}{z} or \compDvect{E}{y}
```

dE_z or $\Delta\mathrm{E}_y$

\scompsdpos
\scompsDpos

symbolic components of the differential of a position vector
\scompsdpos or \scompsDpos

```
\scompsdpos\ or \scompsDpos
```

$\langle \mathrm{d}x, \mathrm{d}y, \mathrm{d}z \rangle$ or $\langle \Delta x, \Delta y, \Delta z \rangle$

\compdpos
\compDpos

one component of the differential of a position vector
\compdpos{⟨*comp*⟩} or \compDpos{⟨*comp*⟩}

```
\compdpos{z} or \compDpos{y}
```

$\mathrm{d}z$ or Δy

\dervect
\Dervect

symbol for the derivative of a vector
\dervect{⟨*kernel*⟩}{⟨*indvar*⟩} or \Dervect{⟨*kernel*⟩}{⟨*indvar*⟩}

```
\dervect{E}{t} or \Dervect{E}{t}
```

$\dfrac{\mathrm{d}\vec{\mathrm{E}}}{\mathrm{d}t}$ or $\dfrac{\Delta\vec{\mathrm{E}}}{\Delta t}$

`\dermagvect`
`\Dermagvect`

symbol for the derivative of the magnitude of a vector
`\dermagvect{`⟨*kernel*⟩`}{`⟨*indvar*⟩`}` or `\Dermagvect{`⟨*kernel*⟩`}{`⟨*indvar*⟩`}`

```
\dermagvect{E}{t} or \Dermagvect{E}{t}
```

$$\frac{\mathrm{d}\left|\vec{\mathrm{E}}\right|}{\mathrm{d}t} \text{ or } \frac{\Delta\left|\vec{\mathrm{E}}\right|}{\Delta t}$$

`\scompsdervect`
`\scompsDervect`

symbolic components of the derivative of a vector
`\scompsdervect{`⟨*kernel*⟩`}{`⟨*indvar*⟩`}` or
`\scompsDervect{`⟨*kernel*⟩`}{`⟨*indvar*⟩`}`

```
\scompsdervect{E}{t} or \scompsDervect{E}{t}
```

$$\left\langle \frac{\mathrm{dE}_x}{\mathrm{d}t}, \frac{\mathrm{dE}_y}{\mathrm{d}t}, \frac{\mathrm{dE}_z}{\mathrm{d}t} \right\rangle \text{ or } \left\langle \frac{\Delta\mathrm{E}_x}{\Delta t}, \frac{\Delta\mathrm{E}_y}{\Delta t}, \frac{\Delta\mathrm{E}_z}{\Delta t} \right\rangle$$

`\compdervect`
`\compDervect`

one component of the derivative of a vector
`\compdervect{`⟨*kernel*⟩`}{`⟨*indvar*⟩`}{`⟨*comp*⟩`}` or
`\compDervect{`⟨*kernel*⟩`}{`⟨*indvar*⟩`}{`⟨*comp*⟩`}`

```
\compdervect{E}{t}{y} or \compDervect{E}{t}{y}
```

$$\frac{\mathrm{dE}_y}{\mathrm{d}t} \text{ or } \frac{\Delta\mathrm{E}_y}{\Delta t}$$

`\magdervect`
`\magDervect`

magnitude of the derivative of a vector
`\magdervect{`⟨*kernel*⟩`}{`⟨*indvar*⟩`}` or `\magDervect{`⟨*kernel*⟩`}{`⟨*indvar*⟩`}`

```
\magdervect{E}{t} or \magDervect{E}{t}
```

$$\left|\frac{\mathrm{d}\vec{\mathrm{E}}}{\mathrm{d}t}\right| \text{ or } \left|\frac{\Delta\vec{\mathrm{E}}}{\Delta t}\right|$$

\scompsderpos
\scompsDerpos

symbolic components of the derivative of a position vector
\scompsderpos{⟨*indvar*⟩} or \scompsDerpos{⟨*indvar*⟩}

```
\scompsderpos{t} or \scompsDerpos{t}
```

$$\left\langle \frac{\mathrm{d}x}{\mathrm{d}t}, \frac{\mathrm{d}y}{\mathrm{d}t}, \frac{\mathrm{d}z}{\mathrm{d}t} \right\rangle \text{ or } \left\langle \frac{\Delta x}{\Delta t}, \frac{\Delta y}{\Delta t}, \frac{\Delta z}{\Delta t} \right\rangle$$

\compderpos
\compDerpos

one component of the derivative of a position vector
\compderpos{⟨*comp*⟩}{⟨*indvar*⟩} or
\compDerpos{⟨*comp*⟩}{⟨*indvar*⟩}

```
\compderpos{z}{t} or \compDerpos{z}{t}
```

$$\frac{\mathrm{d}z}{\mathrm{d}t} \text{ or } \frac{\Delta z}{\Delta t}$$

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 Vectors

Now we have commands for vectors that carry subscripts, 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`
`\magvectsub`
`\dirvectsub`

name magnitude and direction of a subscripted vector
`\vectsub{`⟨*kernel*⟩`}{`⟨*sub*⟩`}`
`\dirvectsub{`⟨*kernel*⟩`}{`⟨*sub*⟩`}`
`\magvectsub{`⟨*kernel*⟩`}{`⟨*sub*⟩`}`

```
\vectsub{p}{ball} and \magvectsub{p}{ball} and \dirvectsub{p}{ball}
```

$\vec{\mathrm{p}}_{\mathrm{ball}}$ and $\left|\vec{\mathrm{p}}_{\mathrm{ball}}\right|$ and $\widehat{\mathrm{p}}_{\mathrm{ball}}$

`\scompsvectsub`

symbolic components of a subscripted vector
`\scompsvectsub{`⟨*kernel*⟩`}{`⟨*sub*⟩`}`

```
\scompsvectsub{p}{ball}
```

$\left\langle \mathrm{p}_{\mathrm{ball},x}, \mathrm{p}_{\mathrm{ball},y}, \mathrm{p}_{\mathrm{ball},z} \right\rangle$

`\compvectsub`

one component of a subscripted vector
`\compvectsub{`⟨*kernel*⟩`}{`⟨*sub*⟩`}{`⟨*comp*⟩`}`

```
\compvectsub{p}{ball}{z}
```

$\mathrm{p}_{\mathrm{ball},z}$

\magvectsubscomps

magnitude of a subscripted vector in terms of its symbolic components
\magvectsubscomps{⟨*kernel*⟩}{⟨*sub*⟩}

```
\magvectsubscomps{p}{ball}
```

$$\sqrt{\mathrm{p}_{\mathrm{ball},x}^{2}+\mathrm{p}_{\mathrm{ball},y}^{2}+\mathrm{p}_{\mathrm{ball},z}^{2}}$$

\scompspossub

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

```
\scompspossub{ball}
```

$$\left\langle x_{\mathrm{ball}}, y_{\mathrm{ball}}, z_{\mathrm{ball}} \right\rangle$$

\comppossub

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

```
\comppossub{ball}{x}
```

$$x_{\mathrm{ball}}$$

\dvectsub
\Dvectsub

differential of a subscripted vector
\dvectsub{⟨*kernel*⟩}{⟨*sub*⟩} or \Dvectsub{⟨*kernel*⟩}{⟨*sub*⟩}

```
\dvectsub{p}{ball} or \Dvectsub{p}{ball}
```

$$\mathrm{d}\vec{\mathrm{p}}_{\mathrm{ball}} \text{ or } \Delta\vec{\mathrm{p}}_{\mathrm{ball}}$$

\scompsdvectsub
\scompsDvectsub

symbolic components the differential of a subscripted vector
\scompsdvectsub{⟨*kernel*⟩}{⟨*sub*⟩} or
\scompsDvectsub{⟨*kernel*⟩}{⟨*sub*⟩}

```
\scompsdvectsub{p}{ball} or \scompsDvectsub{p}{ball}
```

$$\left\langle \mathrm{dp}_{\mathrm{ball},x}, \mathrm{dp}_{\mathrm{ball},y}, \mathrm{dp}_{\mathrm{ball},z} \right\rangle \text{ or } \left\langle \Delta\mathrm{p}_{\mathrm{ball},x}, \Delta\mathrm{p}_{\mathrm{ball},y}, \Delta\mathrm{p}_{\mathrm{ball},z}, \right\rangle$$

`\compdvectsub`
`\compDvectsub`

one component of the differential of a subscripted vector
`\compdvectsub{`⟨*kernel*⟩`}{`⟨*sub*⟩`}{`⟨*comp*⟩`}` or
`\compDvectsub{`⟨*kernel*⟩`}{`⟨*sub*⟩`}{`⟨*comp*⟩`}`

```
\compdvectsub{p}{ball}{y} or \compDvectsub{p}{ball}{y}
```

$\mathrm{dp}_{\mathrm{ball},y}$ or $\Delta\mathrm{p}_{\mathrm{ball},y}$

`\scompsdpossub`
`\scompsDpossub`

symbolic components of the differential of a subscripted position vector
`\scompsdpossub{`⟨*sub*⟩`}` or
`\scompsDpossub{`⟨*sub*⟩`}`

```
\scompsdpossub{ball} or \scompsDpossub{ball}
```

$\left\langle \mathrm{d}x_{\mathrm{ball}}, \mathrm{d}y_{\mathrm{ball}}, \mathrm{d}z_{\mathrm{ball}} \right\rangle$ or $\left\langle \Delta x_{\mathrm{ball}}, \Delta y_{\mathrm{ball}}, \Delta z_{\mathrm{ball}} \right\rangle$

`\compdpossub`
`\compDpossub`

one component of the differential of a subscripted position vector
`\compdpossub{`⟨*sub*⟩`}{`⟨*comp*⟩`}` or
`\compDpossub{`⟨*sub*⟩`}{`⟨*comp*⟩`}`

```
\compdpossub{ball}{x} or \compDpossub{ball}{x}
```

$\mathrm{d}x_{\mathrm{ball}}$ or Δx_{ball}

`\dervectsub`
`\Dervectsub`

derivative of a subscripted vector
`\dervectsub{`⟨*kernel*⟩`}{`⟨*sub*⟩`}{`⟨*indvar*⟩`}` or
`\Dervectsub{`⟨*kernel*⟩`}{`⟨*sub*⟩`}{`⟨*indvar*⟩`}`

```
\dervectsub{p}{ball}{t} or \Dervectsub{p}{ball}{t}
```

$\dfrac{\mathrm{d}\vec{\mathrm{p}}_{\mathrm{ball}}}{\mathrm{d}t}$ or $\dfrac{\Delta\vec{\mathrm{p}}_{\mathrm{ball}}}{\Delta t}$

\dermagvectsub
\Dermagvectsub

symbol for the derivative of the magnitude of a subscripted vector
\dermagvectsub{⟨*kernel*⟩}{⟨*sub*⟩}{⟨*indvar*⟩} or
\Dermagvectsub{⟨*kernel*⟩}{⟨*sub*⟩}{⟨*indvar*⟩}

```
\dermagvectsub{E}{ball}{t} or \Dermagvectsub{E}{ball}{t}
```

$$\frac{\mathrm{d}\left|\vec{\mathrm{E}}_{\mathrm{ball}}\right|}{\mathrm{d}t} \text{ or } \frac{\Delta\left|\vec{\mathrm{E}}_{\mathrm{ball}}\right|}{\Delta t}$$

\scompsdervectsub
\scompsDervectsub

symbolic components of the derivative of a subscripted vector
\scompsdervectsub{⟨*kernel*⟩}{⟨*sub*⟩}{⟨*indvar*⟩} or
\scompsDervectsub{⟨*kernel*⟩}{⟨*sub*⟩}{⟨*indvar*⟩}

```
\scompsdervectsub{p}{ball}{t} or \scompsDervectsub{p}{ball}{t}
```

$$\left\langle \frac{\mathrm{dp}_{\mathrm{ball},x}}{\mathrm{d}t}, \frac{\mathrm{dp}_{\mathrm{ball},y}}{\mathrm{d}t}, \frac{\mathrm{dp}_{\mathrm{ball},z}}{\mathrm{d}t} \right\rangle \text{ or } \left\langle \frac{\Delta\mathrm{p}_{\mathrm{ball},x}}{\Delta t}, \frac{\Delta\mathrm{p}_{\mathrm{ball},y}}{\Delta t}, \frac{\Delta\mathrm{p}_{\mathrm{ball},z}}{\Delta t} \right\rangle$$

\compdervectsub
\compDervectsub

one component of the derivative of a subscripted vector
\compdervectsub{⟨*kernel*⟩}{⟨*sub*⟩}{⟨*indvar*⟩}{⟨*comp*⟩} or
\compDervectsub{⟨*kernel*⟩}{⟨*sub*⟩}{⟨*indvar*⟩}{⟨*comp*⟩}

```
\compdervectsub{p}{ball}{t}{y} or \compDervectsub{p}{ball}{t}{y}
```

$$\frac{\mathrm{dp}_{\mathrm{ball},y}}{\mathrm{d}t} \text{ or } \frac{\Delta\mathrm{p}_{\mathrm{ball},y}}{\Delta t}$$

\magdervectsub
\magDervectsub

magnitude of the derivative of a subscripted vector
\magdervectsub{⟨*kernel*⟩}{⟨*sub*⟩}{⟨*indvar*⟩} or
\magDervectsub{⟨*kernel*⟩}{⟨*sub*⟩}{⟨*indvar*⟩}

```
\magdervectsub{p}{ball}{t} or \magDervectsub{p}{ball}{t}
```

$$\left|\frac{\mathrm{d}\vec{\mathrm{p}}_{\mathrm{ball}}}{\mathrm{d}t}\right| \text{ or } \left|\frac{\Delta\vec{\mathrm{p}}_{\mathrm{ball}}}{\Delta t}\right|$$

\scompsderpossub
\scompsDerpossub

symbolic components of the derivative of an indexed position vector
\scompsderpossub{⟨*sub*⟩}{⟨*indvar*⟩} or
\scompsDerpossub{⟨*sub*⟩}{⟨*indvar*⟩}

```
\scompsderpossub{ball}{t} or \scompsDerpossub{ball}{t}
```

$$\left\langle \frac{\mathrm{d}x_{\mathrm{ball}}}{\mathrm{d}t}, \frac{\mathrm{d}y_{\mathrm{ball}}}{\mathrm{d}t}, \frac{\mathrm{d}z_{\mathrm{ball}}}{\mathrm{d}t} \right\rangle \text{ or } \left\langle \frac{\Delta x_{\mathrm{ball}}}{\Delta t}, \frac{\Delta y_{\mathrm{ball}}}{\Delta t}, \frac{\Delta z_{\mathrm{ball}}}{\Delta t} \right\rangle$$

\compderpossub
\compDerpossub

one component of the derivative of a subscripted position vector
\compderpossub{⟨*sub*⟩}{⟨*indvar*⟩}{⟨*comp*⟩} or
\compDerpossub{⟨*sub*⟩}{⟨*indvar*⟩}{⟨*comp*⟩}

```
\compderpossub{ball}{t}{z} or \compDerpossub{ball}{t}{z}
```

$$\frac{\mathrm{d}z_{\mathrm{ball}}}{\mathrm{d}t} \text{ or } \frac{\Delta z_{\mathrm{ball}}}{\Delta t}$$

5.7.6 Relative Vectors

Sometimes we need the position, velocity, momentum, or force of/on one thing relative to/due to another thing.

\relpos
\relvel
\relmom
\relfor

relative position or velocity or momentum or force vectors for two objects
\relpos{⟨*sub*⟩} and \relvel{⟨*sub*⟩} and \relmom{⟨*sub*⟩}
and \relfor{⟨*sub*⟩}

```
\relpos{12} and \relvel{12} and \relmom{12} and \relfor{12}
```

$\vec{\mathrm{r}}_{12}$ and $\vec{\mathrm{v}}_{12}$ and $\vec{\mathrm{p}}_{12}$ and $\vec{\mathrm{F}}_{12}$

5.7.7 Expressions Containing Dot Products

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
\vectdotsvect
\vectdotevect

dot product of two vectors as a single symbol or with symbolic components or as an expanded sum
\vectdotvect{⟨*vector1*⟩}{⟨*vector2*⟩}
\vectdotsvect{⟨*kernel1*⟩}{⟨*kernel2*⟩}
\vectdotevect{⟨*kernel1*⟩}{⟨*kernel2*⟩}

```
\vectdotvect{\vect{F}}{\vect{v}} \\
\vectdotsvect{F}{v} \\
\vectdotevect{F}{v}
```

$\vec{\mathrm{F}} \bullet \vec{\mathrm{v}}$
$\left\langle \mathrm{F}_x, \mathrm{F}_y, \mathrm{F}_z \right\rangle \bullet \left\langle \mathrm{v}_x, \mathrm{v}_y, \mathrm{v}_z \right\rangle$
$\mathrm{F}_x \mathrm{v}_x + \mathrm{F}_y \mathrm{v}_y + \mathrm{F}_z \mathrm{v}_z$

\vectdotspos
\vectdotepos

dot product of a vector and a position vector with symbolic components or as an expanded sum
\vectdotspos{⟨*kernel*⟩} or \vectdotepos{⟨*kernel*⟩}

```
\vectdotspos{F} \\
\vectdotepos{F}
```

$\left\langle \mathrm{F}_x, \mathrm{F}_y, \mathrm{F}_z \right\rangle \bullet \langle x, y, z \rangle$
$\mathrm{F}_x x + \mathrm{F}_y y + \mathrm{F}_z z$

\vectdotsdvect
\vectdotsDvect
\vectdotedvect
\vectdoteDvect

dot product of a vector and the differential of a vector with symbolic components or expanded as a sum
\vectdotsdvect{⟨*kernel1*⟩}{⟨*kernel2*⟩}
\vectdotsDvect{⟨*kernel1*⟩}{⟨*kernel2*⟩}
\vectdotedvect{⟨*kernel1*⟩}{⟨*kernel2*⟩}
\vectdoteDvect{⟨*kernel1*⟩}{⟨*kernel2*⟩}

```
\vectdotsdvect{F}{r} or \vectdotsDvect{F}{r} \\
\vectdotedvect{F}{r} or \vectdoteDvect{F}{r} \\
```

$\left\langle \mathrm{F}_x, \mathrm{F}_y, \mathrm{F}_z \right\rangle \bullet \left\langle \mathrm{d}r_x, \mathrm{d}r_y, \mathrm{d}r_z \right\rangle$ or $\left\langle \mathrm{F}_x, \mathrm{F}_y, \mathrm{F}_z \right\rangle \bullet \left\langle \Delta \mathrm{r}_x, \Delta \mathrm{r}_y, \Delta \mathrm{r}_z \right\rangle$
$\mathrm{F}_x \mathrm{d}r_x + \mathrm{F}_y \mathrm{d}r_y + \mathrm{F}_z \mathrm{d}r_z$ or $\mathrm{F}_x \Delta \mathrm{r}_x + \mathrm{F}_y \Delta \mathrm{r}_y + \mathrm{F}_z \Delta \mathrm{r}_z$

\vectdotsdpos
\vectdotsDpos
\vectdotedpos
\vectdoteDpos

dot product of a vector and the differential position vector with symbolic components or expanded as a sum
\vectdotsdpos{⟨*kernel*⟩} or \vectdotsDpos{⟨*kernel*⟩}
\vectdotedpos{⟨*kernel*⟩} or \vectdoteDpos{⟨*kernel*⟩}

```
\vectdotsdpos{F} or \vectdotsDpos{F} \\
\vectdotedpos{F} or \vectdoteDpos{F}
```

$\left\langle \mathrm{F}_{x}, \mathrm{F}_{y}, \mathrm{F}_{z} \right\rangle \bullet \langle \mathrm{d}x, \mathrm{d}y, \mathrm{d}z \rangle$ or $\left\langle \mathrm{F}_{x}, \mathrm{F}_{y}, \mathrm{F}_{z} \right\rangle \bullet \langle \Delta x, \Delta y, \Delta z \rangle$
$\mathrm{F}_{x}\,\mathrm{d}x + \mathrm{F}_{y}\,\mathrm{d}y + \mathrm{F}_{z}\,\mathrm{d}z$ or $\mathrm{F}_{x}\,\Delta x + \mathrm{F}_{y}\,\Delta y + \mathrm{F}_{z}\,\Delta z$

\vectsubdotsvectsub
\vectsubdotevectsub

dot product of two subscripted vectors with symbolic components or expanded as a sum
\vectsubdotsvectsub{⟨*kernel1*⟩}{⟨*sub1*⟩}{⟨*kernel2*⟩}{⟨*sub2*⟩}
\vectsubdotevectsub{⟨*kernel1*⟩}{⟨*sub1*⟩}{⟨*kernel2*⟩}{⟨*sub2*⟩}

```
\vectsubdotsvectsub{F}{grav}{r}{ball} \\
\vectsubdotevectsub{F}{grav}{r}{ball}
```

$\left\langle \mathrm{F}_{\mathrm{grav},x}, \mathrm{F}_{\mathrm{grav},y}, \mathrm{F}_{\mathrm{grav},z} \right\rangle \bullet \left\langle \mathrm{r}_{\mathrm{ball},x}, \mathrm{r}_{\mathrm{ball},y}, \mathrm{r}_{\mathrm{ball},z} \right\rangle$
$\mathrm{F}_{\mathrm{grav},x}\,\mathrm{r}_{\mathrm{ball},x} + \mathrm{F}_{\mathrm{grav},y}\,\mathrm{r}_{\mathrm{ball},y} + \mathrm{F}_{\mathrm{grav},z}\,\mathrm{r}_{\mathrm{ball},z}$

\vectsubdotsdvectsub
\vectsubdotsDvectsub
\vectsubdotedvectsub
\vectsubdoteDvectsub

dot product of a subscripted vector and the differential of a subscripted vector with symbolic components or expanded as a sum
\vectsubdotsdvectsub{⟨*kernel1*⟩}{⟨*sub1*⟩}{⟨*kernel2*⟩}{⟨*sub2*⟩}
\vectsubdotsDvectsub{⟨*kernel1*⟩}{⟨*sub1*⟩}{⟨*kernel2*⟩}{⟨*sub2*⟩}
\vectsubdotedvectsub{⟨*kernel1*⟩}{⟨*sub1*⟩}{⟨*kernel2*⟩}{⟨*sub2*⟩}
\vectsubdoteDvectsub{⟨*kernel1*⟩}{⟨*sub1*⟩}{⟨*kernel2*⟩}{⟨*sub2*⟩}

```
\vectsubdotsdvectsub{A}{ball}{B}{car} \\
\vectsubdotsDvectsub{A}{ball}{B}{car} \\
\vectsubdotedvectsub{A}{ball}{B}{car} \\
\vectsubdoteDvectsub{A}{ball}{B}{car}
```

$\left\langle \mathrm{A}_{\mathrm{ball},x}, \mathrm{A}_{\mathrm{ball},y}, \mathrm{A}_{\mathrm{ball},z} \right\rangle \bullet \left\langle \mathrm{dB}_{\mathrm{car},x}, \mathrm{dB}_{\mathrm{car},y}, \mathrm{dB}_{\mathrm{car},z} \right\rangle$
$\left\langle \mathrm{A}_{\mathrm{ball},x}, \mathrm{A}_{\mathrm{ball},y}, \mathrm{A}_{\mathrm{ball},z} \right\rangle \bullet \left\langle \Delta\mathrm{B}_{\mathrm{car},x}, \Delta\mathrm{B}_{\mathrm{car},y}, \Delta\mathrm{B}_{\mathrm{car},z}, \right\rangle$
$\mathrm{A}_{\mathrm{ball},x}\,\mathrm{dB}_{\mathrm{car},x} + \mathrm{A}_{\mathrm{ball},y}\,\mathrm{dB}_{\mathrm{car},y} + \mathrm{A}_{\mathrm{ball},z}\,\mathrm{dB}_{\mathrm{car},z}$
$\mathrm{A}_{\mathrm{ball},x}\,\Delta\mathrm{B}_{\mathrm{car},x} + \mathrm{A}_{\mathrm{ball},y}\,\Delta\mathrm{B}_{\mathrm{car},y} + \mathrm{A}_{\mathrm{ball},z}\,\Delta\mathrm{B}_{\mathrm{car},z}$

\vectsubdotsdvect
\vectsubdotsDvect
\vectsubdotedvect
\vectsubdoteDvect

dot product of a subscripted vector and the differential of a vector with symbolic components or expanded as a sum
\vectsubdotsdvect{⟨*kernel1*⟩}{⟨*sub1*⟩}{⟨*kernel2*⟩}
\vectsubdotsDvect{⟨*kernel1*⟩}{⟨*sub1*⟩}{⟨*kernel2*⟩}
\vectsubdotedvect{⟨*kernel1*⟩}{⟨*sub1*⟩}{⟨*kernel2*⟩}
\vectsubdoteDvect{⟨*kernel1*⟩}{⟨*sub1*⟩}{⟨*kernel2*⟩}

```
\vectsubdotsdvect{A}{ball}{B} \\
\vectsubdotsDvect{A}{ball}{B} \\
\vectsubdotedvect{A}{ball}{B} \\
\vectsubdoteDvect{A}{ball}{B}
```

$$\left\langle \mathrm{A}_{\mathrm{ball},x}, \mathrm{A}_{\mathrm{ball},y}, \mathrm{A}_{\mathrm{ball},z} \right\rangle \bullet \left\langle \mathrm{dB}_{x}, \mathrm{dB}_{y}, \mathrm{dB}_{z} \right\rangle$$
$$\left\langle \mathrm{A}_{\mathrm{ball},x}, \mathrm{A}_{\mathrm{ball},y}, \mathrm{A}_{\mathrm{ball},z} \right\rangle \bullet \left\langle \Delta\mathrm{B}_{x}, \Delta\mathrm{B}_{y}, \Delta\mathrm{B}_{z} \right\rangle$$
$$\mathrm{A}_{\mathrm{ball},x}\,\mathrm{dB}_{x} + \mathrm{A}_{\mathrm{ball},y}\,\mathrm{dB}_{y} + \mathrm{A}_{\mathrm{ball},z}\,\mathrm{dB}_{z}$$
$$\mathrm{A}_{\mathrm{ball},x}\,\Delta\mathrm{B}_{x} + \mathrm{A}_{\mathrm{ball},y}\,\Delta\mathrm{B}_{y} + \mathrm{A}_{\mathrm{ball},z}\,\Delta\mathrm{B}_{z}$$

\vectsubdotsdpos
\vectsubdotsDpos
\vectsubdotedpos
\vectsubdoteDpos

dot product of a subscripted vector and a differential position vector with symbolic components or expanded as a sum
\vectsubdotsdpos{⟨*kernel*⟩}{⟨*sub*⟩}
\vectsubdotsDpos{⟨*kernel*⟩}{⟨*sub*⟩}
\vectsubdotedpos{⟨*kernel*⟩}{⟨*sub*⟩}
\vectsubdoteDpos{⟨*kernel*⟩}{⟨*sub*⟩}

```
\vectsubdotsdpos{A}{ball}\\
\vectsubdotsDpos{A}{ball}\\
\vectsubdotedpos{A}{ball}\\
\vectsubdoteDpos{A}{ball}
```

$$\left\langle \mathrm{A}_{\mathrm{ball},x}, \mathrm{A}_{\mathrm{ball},y}, \mathrm{A}_{\mathrm{ball},z} \right\rangle \bullet \langle \mathrm{d}x, \mathrm{d}y, \mathrm{d}z \rangle$$
$$\left\langle \mathrm{A}_{\mathrm{ball},x}, \mathrm{A}_{\mathrm{ball},y}, \mathrm{A}_{\mathrm{ball},z} \right\rangle \bullet \langle \Delta x, \Delta y, \Delta z \rangle$$
$$\mathrm{A}_{\mathrm{ball},x}\,\mathrm{d}x + \mathrm{A}_{\mathrm{ball},y}\,\mathrm{d}y + \mathrm{A}_{\mathrm{ball},z}\,\mathrm{d}z$$
$$\mathrm{A}_{\mathrm{ball},x}\,\Delta x + \mathrm{A}_{\mathrm{ball},y}\,\Delta y + \mathrm{A}_{\mathrm{ball},z}\,\Delta z$$

\dervectdotsvect
\Dervectdotsvect
\dervectdotevect
\Dervectdotevect

dot product of the derivative of a vector and a vector with symbolic components or expanded as a sum
\dervectdotsvect{⟨*kernel1*⟩}{⟨*indvar*⟩}{⟨*kernel2*⟩}
\Dervectdotsvect{⟨*kernel1*⟩}{⟨*indvar*⟩}{⟨*kernel2*⟩}
\dervectdotevect{⟨*kernel1*⟩}{⟨*indvar*⟩}{⟨*kernel2*⟩}
\Dervectdotevect{⟨*kernel1*⟩}{⟨*indvar*⟩}{⟨*kernel2*⟩}

```
\dervectdotsvect{A}{t}{B} \\
\Dervectdotsvect{A}{t}{B} \\
\dervectdotevect{A}{t}{B} \\
\Dervectdotevect{A}{t}{B}
```

$$\left\langle \frac{\mathrm{dA}_x}{\mathrm{d}t}, \frac{\mathrm{dA}_y}{\mathrm{d}t}, \frac{\mathrm{dA}_z}{\mathrm{d}t} \right\rangle \bullet \left\langle \mathrm{B}_x, \mathrm{B}_y, \mathrm{B}_z \right\rangle$$
$$\left\langle \frac{\Delta \mathrm{A}_x}{\Delta t}, \frac{\Delta \mathrm{A}_y}{\Delta t}, \frac{\Delta \mathrm{A}_z}{\Delta t} \right\rangle \bullet \left\langle \mathrm{B}_x, \mathrm{B}_y, \mathrm{B}_z \right\rangle$$
$$\frac{\mathrm{dA}_x}{\mathrm{d}t}\mathrm{B}_x + \frac{\mathrm{dA}_y}{\mathrm{d}t}\mathrm{B}_y + \frac{\mathrm{dA}_z}{\mathrm{d}t}\mathrm{B}_z$$
$$\frac{\Delta \mathrm{A}_x}{\Delta t}\mathrm{B}_x + \frac{\Delta \mathrm{A}_y}{\Delta t}\mathrm{B}_y + \frac{\Delta \mathrm{A}_z}{\Delta t}\mathrm{B}_z$$

\vectdotsdervect
\vectdotsDervect
\vectdotedervect
\vectdoteDervect

dot product of a vector and the derivative of a vector with symbolic components or expanded as a sum
\vectdotsdervect{⟨*kernel1*⟩}{⟨*kernel2*⟩}{⟨*indvar*⟩}
\vectdotsDervect{⟨*kernel1*⟩}{⟨*kernel2*⟩}{⟨*indvar*⟩}
\vectdotedervect{⟨*kernel1*⟩}{⟨*kernel2*⟩}{⟨*indvar*⟩}
\vectdoteDervect{⟨*kernel1*⟩}{⟨*kernel2*⟩}{⟨*indvar*⟩}

```
\vectdotsdervect{A}{B}{t} \\
\vectdotsDervect{A}{B}{t} \\
\vectdotedervect{A}{B}{t} \\
\vectdoteDervect{A}{B}{t}
```

$$\left\langle \mathrm{A}_x, \mathrm{A}_y, \mathrm{A}_z \right\rangle \bullet \left\langle \frac{\mathrm{dB}_x}{\mathrm{d}t}, \frac{\mathrm{dB}_y}{\mathrm{d}t}, \frac{\mathrm{dB}_z}{\mathrm{d}t} \right\rangle$$
$$\left\langle \mathrm{A}_x, \mathrm{A}_y, \mathrm{A}_z \right\rangle \bullet \left\langle \frac{\Delta \mathrm{B}_x}{\Delta t}, \frac{\Delta \mathrm{B}_y}{\Delta t}, \frac{\Delta \mathrm{B}_z}{\Delta t} \right\rangle$$
$$\mathrm{A}_x \frac{\mathrm{dB}_x}{\mathrm{d}t} + \mathrm{A}_y \frac{\mathrm{dB}_y}{\mathrm{d}t} + \mathrm{A}_z \frac{\mathrm{dB}_z}{\mathrm{d}t}$$
$$\mathrm{A}_x \frac{\Delta \mathrm{B}_x}{\Delta t} + \mathrm{A}_y \frac{\Delta \mathrm{B}_y}{\Delta t} + \mathrm{A}_z \frac{\Delta \mathrm{B}_z}{\Delta t}$$

\dervectdotspos
\Dervectdotspos
\dervectdotepos
\Dervectdotepos

dot product of the derivative of a vector and a position vector using symbolic components or expanded as a sum
\dervectdotspos{⟨*kernel*⟩}{⟨*indvar*⟩}
\Dervectdotspos{⟨*kernel*⟩}{⟨*indvar*⟩}
\dervectdotepos{⟨*kernel*⟩}{⟨*indvar*⟩}
\Dervectdotepos{⟨*kernel*⟩}{⟨*indvar*⟩}

```
\dervectdotspos{A}{t} \\
\Dervectdotspos{A}{t} \\
\dervectdotepos{A}{t} \\
\Dervectdotepos{A}{t}
```

$$\left\langle \frac{\mathrm{dA}_x}{\mathrm{d}t}, \frac{\mathrm{dA}_y}{\mathrm{d}t}, \frac{\mathrm{dA}_z}{\mathrm{d}t} \right\rangle \bullet \langle x, y, z \rangle$$
$$\left\langle \frac{\Delta \mathrm{A}_x}{\Delta t}, \frac{\Delta \mathrm{A}_y}{\Delta t}, \frac{\Delta \mathrm{A}_z}{\Delta t} \right\rangle \bullet \langle x, y, z \rangle$$
$$\frac{\mathrm{dA}_x}{\mathrm{d}t} x + \frac{\mathrm{dA}_y}{\mathrm{d}t} y + \frac{\mathrm{dA}_z}{\mathrm{d}t} z$$
$$\frac{\Delta \mathrm{A}_x}{\Delta t} x + \frac{\Delta \mathrm{A}_y}{\Delta t} y + \frac{\Delta \mathrm{A}_z}{\Delta t} z$$

\dervectdotsdvect
\DervectdotsDvect
\dervectdotedvect
\DervectdoteDvect

dot product of the derivative of a vector and the differential of a vector using symbolic components or expanded as a sum
\dervectdotsdvect{⟨*kernel1*⟩}{⟨*indvar*⟩}{⟨*kernel2*⟩}
\DervectdotsDvect{⟨*kernel1*⟩}{⟨*indvar*⟩}{⟨*kernel2*⟩}
\dervectdotedvect{⟨*kernel1*⟩}{⟨*indvar*⟩}{⟨*kernel2*⟩}
\DervectdoteDvect{⟨*kernel1*⟩}{⟨*indvar*⟩}{⟨*kernel2*⟩}

```
\dervectdotsdvect{A}{t}{B} \\
\DervectdotsDvect{A}{t}{B} \\
\dervectdotedvect{A}{t}{B} \\
\DervectdoteDvect{A}{t}{B}
```

$$\left\langle \frac{\mathrm{dA}_x}{\mathrm{d}t}, \frac{\mathrm{dA}_y}{\mathrm{d}t}, \frac{\mathrm{dA}_z}{\mathrm{d}t} \right\rangle \bullet \left\langle \mathrm{dB}_x, \mathrm{dB}_y, \mathrm{dB}_z \right\rangle$$
$$\left\langle \frac{\Delta \mathrm{A}_x}{\Delta t}, \frac{\Delta \mathrm{A}_y}{\Delta t}, \frac{\Delta \mathrm{A}_z}{\Delta t} \right\rangle \bullet \left\langle \Delta \mathrm{B}_x, \Delta \mathrm{B}_y, \Delta \mathrm{B}_z \right\rangle$$
$$\frac{\mathrm{dA}_x}{\mathrm{d}t} \mathrm{dB}_x + \frac{\mathrm{dA}_y}{\mathrm{d}t} \mathrm{dB}_y + \frac{\mathrm{dA}_z}{\mathrm{d}t} \mathrm{dB}_z$$
$$\frac{\Delta \mathrm{A}_x}{\Delta t} \Delta \mathrm{B}_x + \frac{\Delta \mathrm{A}_y}{\Delta t} \Delta \mathrm{B}_y + \frac{\Delta \mathrm{A}_z}{\Delta t} \Delta \mathrm{B}_z$$

\dervectdotsdpos
\DervectdotsDpos
\dervectdotedpos
\DervectdoteDpos

dot product of the derivative of a vector and the differential of a position vector using symbolic components or expanded as a sum
\dervectdotsdpos{⟨*kernel*⟩}{⟨*indvar*⟩}
\DervectdotsDpos{⟨*kernel*⟩}{⟨*indvar*⟩}
\dervectdotedpos{⟨*kernel*⟩}{⟨*indvar*⟩}
\DervectdoteDpos{⟨*kernel*⟩}{⟨*indvar*⟩}

```
\dervectdotsdpos{A}{t} \\
\DervectdotsDpos{A}{t} \\
\dervectdotedpos{A}{t} \\
\DervectdoteDpos{A}{t}
```

$$\left\langle \frac{\mathrm{dA}_x}{\mathrm{d}t}, \frac{\mathrm{dA}_y}{\mathrm{d}t}, \frac{\mathrm{dA}_z}{\mathrm{d}t} \right\rangle \bullet \langle \mathrm{d}x, \mathrm{d}y, \mathrm{d}z \rangle$$
$$\left\langle \frac{\Delta \mathrm{A}_x}{\Delta t}, \frac{\Delta \mathrm{A}_y}{\Delta t}, \frac{\Delta \mathrm{A}_z}{\Delta t} \right\rangle \bullet \langle \Delta x, \Delta y, \Delta z \rangle$$
$$\frac{\mathrm{dA}_x}{\mathrm{d}t}\mathrm{d}x + \frac{\mathrm{dA}_y}{\mathrm{d}t}\mathrm{d}y + \frac{\mathrm{dA}_z}{\mathrm{d}t}\mathrm{d}z$$
$$\frac{\Delta \mathrm{A}_x}{\Delta t}\Delta x + \frac{\Delta \mathrm{A}_y}{\Delta t}\Delta y + \frac{\Delta \mathrm{A}_z}{\Delta t}\Delta z$$

5.7.8 Basis Vectors and Bivectors

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

\ezero

basis vectors with lower indices 0 to 4 (use \ek or \e for indices > 4)
\zero

```
\ezero \(\cdots\) \efour
```

$$\mathbf{e}_0 \cdots \mathbf{e}_4$$

\uezero

normalized basis vectors with lower indices 0 to 4 (use \uek or \ue for indices > 4)
\uezero

```
\uezero \(\cdots\) \uefour
```

$$\hat{\mathbf{e}}_0 \cdots \hat{\mathbf{e}}_4$$

\ezerozero

basis bivectors with lower indices (use \ek or \e for indices > 4)
\ezerozero

```
\ezerozero \(\cdots\) \efourfour
```

$\mathbf{e}_{00} \cdots \mathbf{e}_{44}$

\euzero

basis vectors with upper indices 0 to 4 (use \euk or \eu for indices > 4)
\euzero

```
\euzero \(\cdots\) \eufour
```

$\mathbf{e}^{0} \cdots \mathbf{e}^{4}$

\euzerozero

basis bivectors with upper indices (use \euk or \eu for indices > 4)
\euzerozero

```
\euzerozero \(\cdots\) \eufourfour
```

$\mathbf{e}^{00} \cdots \mathbf{e}^{44}$

\gzero
\guzero

basis vectors with γ as the kernel (use \guk or \gu for indices > 4)
\gzero or \guzero

```
\gzero \(\cdots\) \gfour \\
\guzero \(\cdots\) \gufour
```

$\gamma_{0} \cdots \gamma_{4}$
$\gamma^{0} \cdots \gamma^{4}$

\gzerozero
\guzerozero

basis bivectors with γ as the kernel (use \guk or \gu for indices > 4)
\gzerozero or \guzerozero

```
\gzerozero \(\cdots\) \gfourfour \\
\guzerozero \(\cdots\) \gufourfour
```

$$\begin{matrix} \gamma_{00} & \cdots & \gamma_{44} \\ \gamma^{00} & & \gamma^{44} \\ \gamma & \cdots & \gamma \end{matrix}$$

\mivector

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

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

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

\colvector

typesets column vectors
\colvect{⟨*commadelimitedlistofcomps*⟩}

```
\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

typesets row vectors
\rowvect{⟨*commadelimitedlistofcomps*⟩}

```
\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

Allow for superscripts.

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

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

$$\vec{\mathrm{p}} = \begin{pmatrix} p_{1} \\ p_{2} \\ p_{3} \end{pmatrix}$$
$$\vec{\mathrm{p}} = \begin{pmatrix} p_{0} \\ p_{1} \\ p_{2} \\ p_{3} \end{pmatrix}$$

\scompsrvect

Allow for superscripts.

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

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

$$\vec{\mathrm{p}} = \begin{pmatrix} p_{1} & p_{2} & p_{3} \end{pmatrix}$$
$$\vec{\mathrm{p}} = \begin{pmatrix} p_{0} & p_{1} & p_{2} & p_{3} \end{pmatrix}$$

5.8 Physical Constants

5.8.1 Defining Physical Constants

`\newphysicsconstant`

define a physical constant
`\newphysicsconstant{`⟨*symbol*⟩`}{`⟨*value*⟩`}{`⟨*foobar*⟩`}{`⟨*baseunits*⟩`}`
`[`⟨*drvdunits*⟩`][`⟨*tradunits*⟩`]`

```
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 `\physconstantmathsymbol` is created that expresses **only** the constant's mathematical symbol.
- A command `\physconstantvalue` is created that expresses **only** the constant's numerical value.
- A command `\physconstant` is created and contains the constant and units typeset according to the options given when `mandi` was loaded.
- A command `\physconstantbaseunit` is created that expresses the constant and its units in *baseunits* form.
- A command `\physconstantdrvdunit` is created that expresses the constant and its units in *drvdunits* form.
- A command `\physconstanttradunit` is created that expresses the constant and its units in *tradunits* form.
- A command `\physconstantonlybaseunit` is created that expresses **only** the constant's units in *baseunits* form.
- A command `\physconstantonlydrvdunit` is created that expresses **only** the constant's units in *drvdunits* form.
- A command `\physconstantonlytradunit` 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
\oofpez

\(\oofpezmathsymbol \approx \oofpez\)

$$\frac{1}{4\pi\epsilon_{\circ}} \approx 9 \times 10^{9}\ \mathrm{N \cdot m^2/C^2}$$

\oofpezcs

alternate form for Coulomb constant
\oofpezcs

\(\oofpezcsmathsymbol = \oofpezcs\)

$$\frac{1}{4\pi\epsilon_{\circ} c^2} = 10^{-7}\ \mathrm{N \cdot s^2/C^2}$$

\epsz

vacuum permittivity
\epsz

\(\epszmathsymbol = \epsz\)

$$\epsilon_{\circ} = 9 \times 10^{-12}\ \mathrm{C^2/N \cdot m^2}$$

\mzofp

Biot-Savart constant
\mzofp

\(\mzofpmathsymbol = \mzofp\)

$$\frac{\mu_{\circ}}{4\pi} = 10^{-7}\ \mathrm{T \cdot m/A}$$

\muz

vacuum permeability
\muz

\(\muzmathsymbol = \muz\)

$\mu_{\circ} = 4\pi \times 10^{-7}\ \mathrm{T \cdot m/A}$

\kboltz

Boltzmann constant
\kboltz

\(\kboltzmathsymbol \approx \kboltz\)

$k_{\mathrm{B}} \approx 1.38 \times 10^{-23}\ \mathrm{J/K}$

\kboltznev

anternate Boltzmann constant
\kboltznev

\(\kboltzmathsymbol \approx \kboltznev\)

$k_{\mathrm{B}} \approx 8.62 \times 10^{-5}\mathrm{eV/K}$

\stefan

Stefan-Boltzmann constant
\stefan

\(\stefanmathsymbol \approx \stefan\)

$\sigma \approx 5.67 \times 10^{-8}\ \mathrm{W/m^2 \cdot K^4}$

\planck

Planck constant
\planck

\(\planckmathsymbol \approx \planck\)

$h \approx 6.62 \times 10^{-34}\ \mathrm{kg \cdot m^2/s}$

\plancknev

alternate Planck constant
\plancknev

\(\planckmathsymbol \approx \plancknev\)

$h \approx 4.136 \times 10^{-15} \mathrm{eV} \cdot \mathrm{s}$

\planckbar

reduced Planck constant (Dirac constant)
\planckbar

\(\planckbarmathsymbol \approx \planckbar\)

$\hbar \approx 1.05 \times 10^{-34} \mathrm{kg} \cdot \mathrm{m}^2/\mathrm{s}$

\planckbarnev

alternate reduced Planck constant (Dirac constant)
\planckbarnev

\(\planckbarmathsymbol \approx \planckbarnev\)

$\hbar \approx 4.136 \times 10^{-15} \mathrm{eV} \cdot \mathrm{s}$

\Navogadro

Avogadro constant
\Navogadro

\(\planckbarmathsymbol \approx \Navogadro\)

$\hbar \approx 6.022 \times 10^{23} \mathrm{mol}^{-1}$

\bigG

gravitational constant
\bigG

\(\bigGmathsymbol \approx \bigG\)

$G \approx 6.67 \times 10^{-11} \mathrm{N} \cdot \mathrm{m}^2/\mathrm{kg}^2$

\littleg

Earth's surface gravitational field strength
\littleg

\(\littlegmathsymbol \approx \littleg\)

$g \approx 9.80 \text{ m/s}^2$

\clight

magnitude of light's velocity
\clight

\(\clightmathsymbol \approx \clight\)

$c \approx 3.00 \times 10^{8} \text{ m/s}$

\clightnfn

magnitude of light's velocity (alternate)
\clightnfn

\(\clightnfn\)

1 ft/ns

\Ratom

approximate atomic radius
\Ratom

\(\Ratommathsymbol \approx \Ratom\)

$r_{\text{atom}} \approx 10^{-10} \text{ m}$

\Mproton

proton's mass
\Mproton

\(\Mprotonmathsymbol \approx \Mproton\)

$m_{\text{proton}} \approx 1.673 \times 10^{-27} \text{ kg}$

`\Mneutron`

neutron's mass
`\Mneutron`

`\(\Mneutronmathsymbol \approx \Mneutron\)`

$m_{\text{neutron}} \approx 1.675 \times 10^{-27}$ kg

`\Mhydrogen`

hydrogen atom's mass
`\Mhydrogen`

`\(\Mhydrogenmathsymbol \approx \Mhydrogen\)`

$m_{\text{hydrogen}} \approx 1.673 \times 10^{-27}$ kg

`\Melectron`

electron's mass
`\Melectron`

`\(\Melectronmathsymbol \approx \Melectron\)`

$m_{\text{electron}} \approx 9.109 \times 10^{-31}$ kg

`\echarge`

elementary charge quantum
`\echarge`

`\(\echargemathsymbol \approx \echarge\)`

$e \approx 1.602 \times 10^{-19}$ C

`\Qelectron`
`\qelectron`

electron's charge
`\Qelectron` or `\qelectron`

`\(\qelectronmathsymbol \approx \qelectron\)`

$q_{\text{electron}} \approx -1.602 \times 10^{-19}$ C

\Qproton
\qproton

proton's charge
\Qproton or \qproton

\(\qprotonmathsymbol \approx \qproton\)

$q_{\text{proton}} \approx +1.602 \times 10^{-19}$ C

\MEarth

Earth's mass
\MEarth

\(\MEarthmathsymbol \approx \MEarth\)

$M_{\text{Earth}} \approx 6 \times 10^{24}$ kg

\MMoon

Moon's mass
\MMoon

\(\MMoonmathsymbol \approx \MMoon\)

$M_{\text{Moon}} \approx 7 \times 10^{22}$ kg

\MSun

Sun's mass
\MSun

\(\MSunmathsymbol \approx \MSun\)

$M_{\text{Sun}} \approx 2 \times 10^{30}$ kg

\REarth

Earth's radius
\REarth

\(\REarthmathsymbol \approx \REarth\)

$R_{\text{Earth}} \approx 6.4 \times 10^{6}$ m

\RMoon

Moon's radius
\RMoon

\(\RMoonmathsymbol \approx \RMoon\)

$R_{\text{Moon}} \approx 1.75 \times 10^{6}$ m

\RSun

Sun's radius
\RSun

\(\RSunmathsymbol \approx \RSun\)

$R_{\text{Sun}} \approx 7 \times 10^{8}$ m

\ESdist

Sun-Earth distance or Earth-Sun distance
\ESdist or \SEdist

\(\ESdistmathsymbol \approx \SEdist\)

$\left|\vec{r}_{\text{ES}}\right| \approx 1.5 \times 10^{11}$ m

\EMdist

Earth-Moon distance or Moon-Earth distance
\EMdist or \MEdist

\(\EMdistmathsymbol \approx \EMdist\)

$\left|\vec{r}_{\text{EM}}\right| \approx 4 \times 10^{8}$ m

5.9 Astronomical Constants and Quantities

\lightyear

various ways of denoting light years and years and parsecs as units

```
\lightyear\ or \Lightyear\ or \cyear\ or \cyr\ or \yyear\ or \yr \\
\parsec
```

ly or LY or $c \cdot$ year or $c \cdot$ yr or year or yr
pc

\LSun

Sun's luminosity
\LSun

```
\(\LSunmathsymbol \approx \LSun\)
```

$L_{\text{Sun}} \approx 4 \times 10^{26}$ J/s

\TSun

Sun's effective temperature
\TSun

```
\(\TSunmathsymbol \approx \TSun\)
```

$T_{\text{Sun}} \approx 5800$ K

\MagSun

Sun's absolute magnitude
\MagSun

```
\(\MagSunmathsymbol \approx \MagSun\)
```

$M_{\text{Sun}} \approx +4.83$

\magSun

Sun's apparent magnitude
\magSun

```
\(\magSunmathsymbol \approx \magSun\)
```

$m_{\text{Sun}} \approx -26.74$

`\Lstar`

stellar luminosity
`\Lstar[`⟨*object*⟩`]`

`\Lstar or \Lstar[Sirius] or \Lsolar`

$L_\star$ or L_{Sirius} or $L_\odot$

`\Tstar`

stellar and solar temperature
`\Tstar[`⟨*object*⟩`]`

`\Tstar or \Tstar[Sirius] or \Tsolar`

$T_\star$ or T_{Sirius} or $T_\odot$

`\Rstar`

stellar and solar radius
`\Rstar[`⟨*object*⟩`]`

`\Rstar or \Rstar[Sirius] or \Rsolar`

$R_\star$ or R_{Sirius} or $R_\odot$

`\Mstar`

stellar and solar mass
`\Mstar[`⟨*object*⟩`]`

`\Mstar or \Mstar[Sirius] or \Msolar`

$M_\star$ or M_{Sirius} or $M_\odot$

`\Fstar`
`\fstar`

stellar and solar flux
`\Fstar[`⟨*object*⟩`]` or `\fstar[`⟨*object*⟩`]`

`\Fstar or \Fstar[Sirius] or \FSun or \Fsolar or \fstar or`
`\fstar[Sirius] or \fSun or \fsolar`

$F_\star$ or F_{Sirius} or F_{Sun} or $F_\odot$ or $f_\star$ or f_{Sirius} or f_{Sun} or $f_\odot$

\Magstar
\magstar

stellar and solar magnitude
\Magstar[⟨*object*⟩] or \magstar[⟨*object*⟩]

```
\Magstar or \Magstar[Sirius] or \magstar or \magstar[Sirius] or
\Magsolar or \magsolar
```

$M_\star$ or M_{Sirius} or $m_\star$ or m_{Sirius} or $M_\odot$ or $m_\odot$

\Dstar
\dstar

stellar and solar distance (or diameter)
\Dstar[⟨*object*⟩] or \dstar[⟨*object*⟩]

```
\Dstar or \Dstar[Sirius] or \Dsolar or \dstar or \dstar[Sirius] or
\dsolar
```

$D_\star$ or D_{Sirius} or $D_\odot$ or $d_\star$ or d_{Sirius} or $d_\odot$

5.10 Frequently Used Fractions

\onehalf

small fractions with numerator 1
\onehalf

```
\(\onehalf \cdots \onetenth\)
```

$\frac{1}{2} \cdots \frac{1}{10}$

\twothirds

small fractions with numerator 2
\twothirds

```
\(\twothirds \cdots \twoninths\)
```

$\frac{2}{3} \cdots \frac{2}{9}$

\threehalves

small fractions with numerator 3
\threehalves

```
\(\threehalves \cdots \threetenths\)
```

$$\frac{3}{2} \cdots \frac{3}{10}$$

\fourthirds

small fractions with numerator 4
\fourthirds

```
\fourthirds
```

$$\frac{4}{3}$$

5.11 Calculus

\dx

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

```
\[ \int y^{2}\dx{y} \]
```

$$\int y^2 \,\mathrm{d}y$$

\evalfromto

properly typesets evaluation of definite integrals
\evalfromto{⟨*antiderivative*⟩}{⟨*lowerlimit*⟩}{⟨*upperlimit*⟩}

```
\[ \evalfromto{\onethird y^3}{0}{3} \]
```

$$\frac{1}{3}y^3\Big|_0^3$$

\evalat

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

```
\[ \evalat{\dbydt[x]}{t=1} \]
```

$$\frac{\mathrm{d}x}{\mathrm{d}t}\Big|_{t=1}$$

Combine with \evaluatedat?

\evaluatedat

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

```
\[ \mbox{LMST}\evaluatedat{\longitude{0}} \]
```

$$\mathrm{LMST}\Big|_{0^\circ}$$

`\integral`
`\Integral`

typesets indefinite and definite integrals
`\integral[`⟨*lowerlimit*⟩`][`⟨*upperlimit*⟩`]{`⟨*integrand*⟩`}{`⟨*variable*⟩`}`
`\Integral[`⟨*lowerlimit*⟩`][`⟨*upperlimit*⟩`]{`⟨*integrand*⟩`}{`⟨*variable*⟩`}`

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

$$\int y^2 \,\mathrm{d}y$$

$$\int_{y=0}^{y=3} y^2 \,\mathrm{d}y$$

$$\int y^2 \,\mathrm{d}y$$

$$\int_{y=0}^{y=3} y^2 \,\mathrm{d}y$$

`\opensurfintegral`
`\opensurfIntegral`

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

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

$$\int_S \vec{\mathrm{E}} \bullet \hat{\mathrm{n}}\,\mathrm{d}A$$

$$\int\limits_{\mathbf{S}} \vec{\mathrm{E}} \bullet \hat{\mathrm{n}}\,\mathrm{d}A$$

`\closedsurfintegral`
`\closedsurfIntegral`

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

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

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

$$\oint\limits_{\mathbf{S}} \vec{\mathrm{E}} \bullet \hat{\mathrm{n}}\,\mathrm{d}A$$

`\openlineintegral`
`\openlineIntegral`

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

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

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

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

`\closedlineintegral`
`\closedlineIntegral`

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

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

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

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

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
\DbyDt

first time derivative operator with optional operand
`\dbydt[`⟨*operand*⟩`]` or `\DbyDt[`⟨*operand*⟩`]`

```
\[ \dbydt \]
\[ \dbydt x \]
\[ \dbydt[x] \]
\[ \DbyDt \]
\[ \DbyDt x \]
\[ \DbyDt[x] \]
```

$$\frac{\mathrm{d}}{\mathrm{d}t}$$
$$\frac{\mathrm{d}}{\mathrm{d}t}x$$
$$\frac{\mathrm{d}x}{\mathrm{d}t}$$
$$\frac{\Delta}{\Delta t}$$
$$\frac{\Delta}{\Delta t}x$$
$$\frac{\Delta x}{\Delta t}$$

\ddbydt
\DDbyDt

second time derivative operator with optional operand
`\ddbydt[`⟨*operand*⟩`]` or `\DDbyDt[`⟨*operand*⟩`]`

```
\[ \ddbydt \]
\[ \ddbydt x \]
\[ \ddbydt[x] \]
\[ \DDbyDt \]
\[ \DDbyDt x \]
\[ \DDbyDt[x] \]
```

$$\frac{\mathrm{d}^2}{\mathrm{d}t^2}$$
$$\frac{\mathrm{d}^2}{\mathrm{d}t^2}x$$
$$\frac{\mathrm{d}^2x}{\mathrm{d}t^2}$$
$$\frac{\Delta^2}{\Delta t^2}$$
$$\frac{\Delta^2}{\Delta t^2}x$$
$$\frac{\Delta^2x}{\Delta t^2}$$

\pbypt

first time partial derivative operator with optional operand
`\pbypt[`⟨*operand*⟩`]`

```
\[ \pbypt \]
\[ \pbypt x \]
\[ \pbypt[x] \]
```

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

\ppbypt

second time partial derivative operator with optional operand
\ppbypt[⟨*operand*⟩]

```
\[ \ppbypt \]
\[ \ppbypt x \]
\[ \ppbypt[x] \]
```

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

\dbyd
\DbyD

generic first derivative operator
\dbyd{⟨*dependentvariable*⟩}{⟨*indvar*⟩} or \dbyd{⟨*dependentvariable*⟩} {⟨*indvar*⟩}

```
\[ \dbyd{f}{y} \]
\[ \DbyD{f}{y} \]
```

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

\ddbyd
\DDbyD

generic second derivative operator
\ddbyd{⟨*dependentvariable*⟩}{⟨*indvar*⟩} or \ddbyd{⟨*dependentvariable*⟩} {⟨*indvar*⟩}

```
\[ \ddbyd{f}{y} \]
\[ \DDbyD{f}{y} \]
```

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

\pbyp

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

```
\[ \pbyp{f}{y} \]
```

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

\ppbyp

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

```
\[ \ppbyp{f}{y} \]
```

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

\divergence
\curl

divergence and curl of a quantity (you must explicitly provide an arrow with \vect if you want one)
\divergence{⟨*vector*⟩} and \curl{⟨*vector*⟩}

```
\divergence{\vect{E}} and \curl{\vect{E}}
```

$\nabla \bullet \vec{\mathrm{E}}$ and $\nabla \times \vec{\mathrm{E}}$

\seriesofx

series expansion of $f\left(x\right)$
\seriesofx

```
\seriesofx
```

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

`\seriesexpx`

series expansion of e^x
`\seriesexpx`

```
\seriesexpx
```

$$e^x \approx 1 + x + \frac{x^2}{2!} + \frac{x^3}{3!} + \dots$$

`\seriessinx`

series expansion of $\sin x$
`\seriessinx`

```
\seriessinx
```

$$\sin x \approx x - \frac{x^3}{3!} + \frac{x^5}{5!} - \dots$$

`\seriescosx`

series expansion of $\cos x$
`\seriescosx`

```
\seriescosx
```

$$\cos x \approx 1 - \frac{x^2}{2!} + \frac{x^4}{4!} - \dots$$

`\seriestanx`

series expansion of $\tan x$
`\seriestanx`

```
\seriestanx
```

$$\tan x \approx x + \frac{x^3}{3} + \frac{2x^5}{15} + \dots$$

`\seriesatox`

series expansion of a^x
`\seriesatox`

```
\seriesatox
```

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

\serieslnoneplusx

series expansion of $\ln(1+x)$
\serieslnoneplusx

```
\serieslnoneplusx
```

$$\ln(1 \pm x) \approx \pm x - \frac{x^2}{2} \pm \frac{x^3}{3} - \frac{x^4}{4} \pm \dots$$

\binomialseries

series expansion of $(1+x)^n$
\binomialseries

```
\binomialseries
```

$$(1+x)^n \approx 1 + nx + \frac{n(n-1)}{2!}x^2 + \dots$$

\diracdelta

Dirac delta function
\diracdelta{⟨*arg*⟩}

```
\diracdelta{x}
```

$$\boldsymbol{\delta}(x)$$

5.12 Other Useful Commands

\asin
\acos
\atan
\asec
\acsc
\acot

trigonometric and inverse trigonometric functions not defined in LaTeX
\asin and \acos and \atan and \asec and \acsc and \acot

```
\(\asin\) and \(\acos\) and \(\atan\) and \(\asec\) and \(\acsc\) and
    \(\acot\)
```

$\sin^{-1}$ and $\cos^{-1}$ and $\tan^{-1}$ and $\sec^{-1}$ and $\csc^{-1}$ and $\cot^{-1}$

\sech
\csch
\asinh
\acosh
\atanh
\asech
\acsch
\acoth

hyperbolic and inverse hyperbolic functions not defined in LaTeX
\sech and \csch and \asinh and \acosh
\atanh and \asech and \acsch and \acoth

```
\(\sech\) and \(\csch\) and \(\asinh\) and \(\acosh\) \\
\(\atanh\) and \(\asech\) and \(\acsch\) and \(\acoth\)
```

sech and csch and $\sinh^{-1}$ and $\cosh^{-1}$
$\tanh^{-1}$ and sech^{-1} and csch^{-1} and $\coth^{-1}$

\sgn

signum function
\sgn

```
\(\sgn\)
```

sgn

\dex

decimal exponentiation function (used in astrophysics)
\dex

```
\(\dex\)
```

dex

\eV
\ev

shortcuts for \electronvolt
\eV or \ev

```
\eV\ or \eV
```

eV or eV

\emf

symbol for electromotive force
\emf

```
\emf
```

emf

\logb

logarithms to arbitrary bases
\logb[⟨*base*⟩]

```
\logb 8 or \logb[2] 8
```

$\log 8$ or $\log_{2} 8$

\cB

alternate symbol for magnetic field inspired by Tom Moore
\cB

```
\cB\ or \vect{\cB}
```

$\mathcal{B}$ or $\vec{\mathcal{B}}$

\newpi

Bob Palais' symbol for 2π
\newpi

```
\newpi
```

π

\scripty

use to get fonts in Griffith's electrodynamics textbook
\scripty{⟨*kernel*⟩}

```
\scripty{r}
```

$\mathscr{r}$

\flux

symbol for flux of a vector field
\flux[⟨*label*⟩]

```
\flux or \flux[E]
```

Φ or Φ_{E}

\abs

absolute value function
\abs{⟨*arg*⟩}

```
\abs{-4}
```

$|-4|$

\magof

magnitude of a quantity (lets you selectively use double bars without setting the **doubleabsbars** option)
\magof{⟨*arg*⟩}

```
\magof{\vect{E}}
```

$\left\|\vec{\mathrm{E}}\right\|$

\dimsof

notation for showing the dimensions of a quantity
\dimsof{⟨*arg*⟩}

```
\(\dimsof{\vect{v}} = L \cdot T^{-1}\)
```

$[\vec{\mathrm{v}}] = L \cdot T^{-1}$

\unitsof

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{⟨*arg*⟩}

```
\unitsof{\vect{v}} = \m\per\s
```

$[\vec{\mathrm{v}}]_u = \mathrm{m/s}$

`\quant`
`\bquant`

surrounds the argument with variable sized parentheses (use `\bquant` to get square brackets)
`\quant{`⟨*arg*⟩`}` or `\bquant{`⟨*arg*⟩`}`

```
\quant{\oofpez} or \bquant{\oofpez}
```

$\left(9 \times 10^{9}\ \mathrm{N \cdot m^2/C^2}\right)$ or $\left[9 \times 10^{9}\ \mathrm{N \cdot m^2/C^2}\right]$

`\Changein`
`\changein`

notation for *the change in a quantity*
`\Changein{`⟨*quantity*⟩`}` or `\changein{`⟨*quantity*⟩`}`

```
\Changein{\vect{E}} or \changein{\vect{E}}
```

$\Delta\vec{\mathrm{E}}$ or $\delta\vec{\mathrm{E}}$

`\scin`
`\ee`
`\EE`

scientific notation (use `\ee` or `\EE` for computer code)
`\scin[`⟨*mantissa*⟩`]{`⟨*exponent*⟩`}[`⟨*unit*⟩`]`
`\ee{`⟨*mantissa*⟩`}{`⟨*exponent*⟩`}`
`\EE{`⟨*mantissa*⟩`}{`⟨*exponent*⟩`}`

```
\scin[2.99]{8}[\m\per\s] \\
\ee{2.99}{8} \\
\EE{2.99}{8}
```

$2.99 \times 10^{8}\ \mathrm{m/s}$
2.99e8
2.99E8

\dms
\hms
\clockreading

formatted angles and times
\dms{⟨deg⟩}{⟨min⟩}{⟨sec⟩}
\hms{⟨hour⟩}{⟨min⟩}{⟨sec⟩}
\clock reading{⟨hour⟩}{⟨minute⟩}{⟨second⟩}

```
\dms{23}{34}{10.27} \\
\hms{23}{34}{10.27} \\
\clockreading{23}{34}{10.27}
```

$23^\circ 34' 10.27''$
$23^{\mathrm{h}}34^{\mathrm{m}}10.27^{\mathrm{s}}$
$23^{\mathrm{h}}34^{\mathrm{m}}10.27^{\mathrm{s}}$

\latitude
\latitudeN
\latitudeS
\longitude
\longitudeE
\longitudeW

formatted latitude and longitude

```
\latitude{+35} or \latitudeN{35} or \latitudeS{35} \\
\longitude{-81} or \longitudeE{81} or \longitudeW{81}
```

$+35^\circ$ or 35° N or 35° S
-81° or 81° E or 81° W

\ssub

text subscripts
\ssub{⟨kernel⟩}{⟨sub⟩}

```
\ssub{N}{AB}
```

N_{AB}

\ssup

text superscripts
\ssup{⟨kernel⟩}{⟨sup⟩}

```
\ssup{N}{contact}
```

N^{contact}

\ssud

text superscripts and subscripts
\ssud{⟨*kernel*⟩}{⟨*sup*⟩}{⟨*sub*⟩}

```
\ssud{N}{contact}{AB}
```

$$N_{\mathrm{AB}}^{\mathrm{contact}}$$

\msub

mathematical subscripts
\msub{⟨*kernel*⟩}{⟨*sub*⟩}

```
\msub{R}{\alpha\beta}
```

$$R_{\alpha\beta}$$

\msup

mathematical superscripts
\msup{⟨*kernel*⟩}{⟨*sup*⟩}

```
\msup{R}{\gamma}
```

$$R^{\gamma}$$

\msud

mathematical superscripts and subscripts
\msud{⟨*kernel*⟩}{⟨*sup*⟩}{⟨*sub*⟩}

```
\msud{\Gamma}{\gamma}{\alpha\beta}
```

$$\Gamma_{\alpha\beta}^{\gamma}$$

\levicivita

Levi-Civita symbol
\levicivita{⟨*indices*⟩}

```
\levicivita{ijk}
```

$$\varepsilon_{ijk}$$

\xaxis
\yaxis
\zaxis
\naxis

shortcuts for coordinate axes
\xaxis or \yaxis or \zaxis or \naxis{⟨axis⟩}

```
\xaxis or \yaxis or \zaxis or \naxis{t}
```

x-axis or y-axis or z-axis or t-axis

\xyplane
\yzplane
\zxplane
\yxplane
\zyplane
\xzplane

shortcuts for coordinate planes
\xyplane or \yzplane or \zxplane or \yzplane or \zyplane or \xzplane

```
\xyplane or \yzplane or \zxplane or \yxplane or \zyplane or \xzplane
```

xy-plane or yz-plane or zx-plane or yx-plane or zy-plane or xz-plane

\cuberoot
\fourthroot
\fifthroot
\fsqrt
\fcuberoot
\ffourthroot
\ffifthroot

frequently used roots as radicals
\cuberoot{⟨arg⟩} or \fourthroot{⟨arg⟩} or \fifthroot{⟨arg⟩} or \fsqrt{⟨arg⟩} or \fcuberoot{⟨arg⟩} or \ffourthroot{⟨arg⟩} or \ffifthroot{⟨arg⟩}

```
\cuberoot{x} or \fourthroot{x} or \fifthroot{x} or \fsqrt{x}
or \fcuberoot{x} or \ffourthroot{x} or \ffifthroot{x}
```

$\sqrt[3]{x}$ or $\sqrt[4]{x}$ or $\sqrt[5]{x}$ or $x^{\frac{1}{2}}$ or $x^{\frac{1}{3}}$ or $x^{\frac{1}{4}}$ or $x^{\frac{1}{5}}$

\relgamma
\frelgamma

expressions for relativistic gamma factor
\relgamma{⟨arg⟩} or \frelgamma{⟨arg⟩}

```
\relgamma{\magvect{v}} or \relgamma{(0.5c)} \\
\frelgamma{\magvect{v}} or \frelgamma{(0.5c)}
```

$$\frac{1}{\sqrt{1-\left(\frac{|\vec{\mathrm{v}}|}{c}\right)^2}} \text{ or } \frac{1}{\sqrt{1-\left(\frac{(0.5c)}{c}\right)^2}}$$

$$\left(1-\frac{|\vec{\mathrm{v}}|^2}{c^2}\right)^{-\frac{1}{2}} \text{ or } \left(1-\frac{(0.5c)^2}{c^2}\right)^{-\frac{1}{2}}$$

\oosqrtomxs
\oosqrtomx
\ooomx
\ooopx

expressions convenient for numerically evaluating γ
\oosqrtomxs{⟨*arg*⟩} (*one over square root of one minus x squared*)
\oosqrtomx{⟨*arg*⟩} (*one over square root of one minus x*)
\ooomx{⟨*arg*⟩} (*one over one minus x*)
\ooopx{⟨*arg*⟩} (*one over one plus x*)

```
\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

\isequals

typesets *test-for-equality* operator
\isequals

```
5 \isequals 3
```

$5 \stackrel{?}{=} 3$

\wordoperator
\pwordoperator

typesets two lines of tiny text to be use as an operator without using mathematical symbols
\wordoperator{⟨*firstline*⟩}{⟨*secondline*⟩}
\pwordoperator{⟨*firstline*⟩}{⟨*secondline*⟩}

```
\wordoperator{added}{to} \\
\pwordoperator{added}{to}
```

$\underset{\text{to}}{\text{added}}$
$\left(\underset{\text{to}}{\text{added}}\right)$

\definedas
\associated
\adjustedby
\earlierthan
\laterthan
\forevery

frequently used word operators
\definedas or \associated or \adjustedby or \earlierthan or \laterthan or \forevery

```
\definedas or \associated or \adjustedby \\
\earlierthan or \laterthan or \forevery
```

$\overset{\text{defined}}{\text{as}}$ or $\overset{\text{associated}}{\text{with}}$ or $\overset{\text{adjusted}}{\text{by}}$
$\overset{\text{earlier}}{\text{than}}$ or $\overset{\text{later}}{\text{than}}$ or $\overset{\text{for}}{\text{every}}$

\pdefinedas
\passociated
\padjustedby
\pearlierthan
\platerthan
\pforevery

frequently used word operators with parentheses
\pdefinedas or \passociated or \padjustedby or \pearlierthan or \platerthan or \pforevery

```
\pdefinedas or \passociated or \padjustedby \\
\pearlierthan or \platerthan or \pforevery
```

$\binom{\text{defined}}{\text{as}}$ or $\binom{\text{associated}}{\text{with}}$ or $\binom{\text{adjusted}}{\text{by}}$
$\binom{\text{earlier}}{\text{than}}$ or $\binom{\text{later}}{\text{than}}$ or $\binom{\text{for}}{\text{every}}$

\defines

defines or *defined by* operator
\defines

```
\vect{p} \defines \(\gamma m\)\vect{v}
```

$\vec{\mathrm{p}} \overset{\text{def}}{=} \gamma m \vec{\mathrm{v}}$

\inframe

operator for indicating the coordinate representation of a vector in a particular reference frame denoted by a capital letter
\inframe[⟨*frame*⟩]

```
\vect{p} \inframe[S] \momentum{\mivector{1,2,3}} \\
\vect{p} \inframe[S'] \momentum{\mivector{\sqrt{14},0,0}}
```

$\vec{\mathrm{p}} \underset{\mathcal{S}}{\longrightarrow} \langle 1, 2, 3 \rangle \ \mathrm{kg \cdot m/s}$
$\vec{\mathrm{p}} \underset{\mathcal{S}'}{\longrightarrow} \left\langle \sqrt{14}, 0, 0 \right\rangle \ \mathrm{kg \cdot m/s}$

Make the arrow's length fixed.

\associates

associated with or *associates with* operator (for verbal concepts)
\associates

```
kinetic energy \associates velocity
```

kinetic energy $\xrightarrow{\text{assoc}}$ velocity

\becomes

becomes operator
\becomes

```
\(\gamma m\)\vect{v} \becomes \(m\)\vect{v}
```

$\gamma m\vec{\mathrm{v}} \xrightarrow{\text{becomes}} m\vec{\mathrm{v}}$

\rrelatedto
\lrelatedto
\brelatedto

operators for directional mathematical relationships without mathematical notation
\rrelatedto{⟨*loperation*⟩}
\lrelatedto{⟨*roperation*⟩}
\brelatedto{⟨*loperation*⟩}{⟨*roperation*⟩}

```
(flux ratio) \rrelatedto{taking logarithm} (mag diff) \\
(flux ratio) \lrelatedto{exponentiation} (mag diff) \\
(mag diff) \brelatedto{taking logarithm}{exponentiation}(flux ratio)
```

(flux ratio) $\xRightarrow{\text{taking logarithm}}$ (mag diff)
(flux ratio) $\xLeftarrow[\text{exponentiation}]{}$ (mag diff)
(mag diff) $\xRightleftharpoons[\text{taking logarithm}]{\text{exponentiation}}$(flux ratio)

5.14 Commands Specific to *Matter & Interactions*

`\momprinciple`

momentum principle
`\LHSmomprinciple` or `\RHSmomprinciple` or `\momprinciple`

```
\LHSmomprinciple \\
\RHSmomprinciple \\
\momprinciple
```

$$\vec{\mathrm{p}}_{\mathrm{sys,f}}$$
$$\vec{\mathrm{p}}_{\mathrm{sys,i}} + \vec{\mathrm{F}}_{\mathrm{net,sys}}\Delta t$$
$$\vec{\mathrm{p}}_{\mathrm{sys,f}} = \vec{\mathrm{p}}_{\mathrm{sys,i}} + \vec{\mathrm{F}}_{\mathrm{net,sys}}\Delta t$$

`\energyprinciple`

energy principle
`\LHSenergyprinciple` or `\RHSenergyprinciple` or `\energyprinciple`

```
\LHSenergyprinciple \\
\RHSenergyprinciple \\
\energyprinciple
```

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

`\angularmomprinciple`

angular momentum principle
`\LHSangularmomprinciple` or `\RHSangularmomprinciple` or `\angularmomprinciple`

```
\LHSangularmomprinciple \\
\RHSangularmomprinciple \\
\angularmomprinciple
```

$$\vec{\mathrm{L}}_{\mathrm{sys,A,f}}$$
$$\vec{\mathrm{L}}_{\mathrm{sys,A,i}} + \vec{\mathrm{T}}_{\mathrm{net,sys}}\Delta t$$
$$\vec{\mathrm{L}}_{\mathrm{sys,A,f}} = \vec{\mathrm{L}}_{\mathrm{sys,A,i}} + \vec{\mathrm{T}}_{\mathrm{net,sys}}\Delta t$$

\gravinteraction

expression for gravitational interaction
\gravinteraction

```
\gravinteraction
```

$$G\frac{M_1 M_2}{\left|\vec{r}_{12}\right|^2}\left(-\hat{r}_{12}\right)$$

\elecinteraction

xxpression for electric interaction
\elecinteraction

```
\elecinteraction
```

$$\frac{1}{4\pi\epsilon_o}\frac{Q_1 Q_2}{\left|\vec{r}_{12}\right|^2}\hat{r}_{12}$$

\Efieldofparticle

expression for electric field of a particle
\Efieldofparticle

```
\Efieldofparticle
```

$$\frac{1}{4\pi\epsilon_o}\frac{Q}{|\vec{r}|^2}\hat{r}$$

\Bfieldofparticle

expression for magnetic field of a particle
\Bfieldofparticle

```
\Bfieldofparticle
```

$$\frac{\mu_o}{4\pi}\frac{Q\,|\vec{v}|}{|\vec{r}|^2}\hat{v}\times\hat{r}$$

\Esys

symbol for energy of system
\Esys

\Esys

E_{sys}

\Us

symbol for spring potential energy
\Us

\Us

U_{s}

\Ug

symbol for gravitational potential energy
\Ug

\Ug

U_{g}

\Ue

symbol for electric potential energy
\Ue

\Ue

U_{e}

\Ktrans

symbol for translational kinetic energy
\Ktrans

\Ktrans

K_{trans}

\Krot

symbol for rotational kinetic energy
\Krot

\Krot

K_{rot}

\Eparticle

symbol for particle energy
\Eparticle

\Eparticle

E_{particle}

\Einternal

symbol for internal energy
\Einternal

\Einternal

E_{internal}

\Erest

symbol for rest energy
\Erest

\Erest

E_{rest}

\Echem

symbol for chemical energy
\Echem

\Echem

E_{chem}

\Etherm

symbol for thermal energy
\Etherm

```
\Etherm
```

E_{therm}

\Evib

symbol for vibrational energy
\Evib

```
\Evib
```

E_{vib}

\Ephoton

symbol for photon energy
\Ephoton

```
\Ephoton
```

E_{photon}

\DUs

symbol for change in spring potential energy
\DUs

```
\DUs
```

ΔU_{s}

\DUg

symbol for change in gravitational potential energy
\DUg

```
\DUg
```

ΔU_{g}

\DUe

symbol for change in electric potential energy
\DUe

\DUe

ΔU_{e}

\DKtrans

symbol for change in translational kinetic energy
\DKtrans

\DKtrans

$\Delta K_{\mathrm{trans}}$

\DKrot

symbol for change in rotational kinetic energy
\DKrot

\DKrot

ΔK_{rot}

\DEparticle

symbol for change in particle energy
\DEparticle

\DEparticle

$\Delta E_{\mathrm{particle}}$

\DEinternal

symbol for change in internal energy
\DEinternal

\DEinternal

$\Delta E_{\mathrm{internal}}$

\DErest

symbol for change in rest energy
\DErest

\DErest

ΔE_{rest}

\DEchem

symbol for change in chemical energy
\DEchem

\DEchem

ΔE_{chem}

\DEtherm

symbol for change in thermal energy
\DEtherm

\DEtherm

ΔE_{therm}

\DEvib

symbol for change in vibrational energy
\DEvib

\DEvib

ΔE_{vib}

\DEphoton

symbol for change in photon energy
\DEphoton

\DEphoton

ΔE_{photon}

\Usfinal

expression for final spring potential energy
\Usfinal

\Usfinal

$$\left(\frac{1}{2}k_{\mathrm{s}}s^{2}\right)_{\mathrm{f}}$$

\Usinitial

expression for initial spring potential energy
\Usinitial

\Usfinal

$$\left(\frac{1}{2}k_{\mathrm{s}}s^{2}\right)_{\mathrm{f}}$$

\Ugfinal

expression for final gravitational potential energy
\Ugfinal

\Ugfinal

$$\left(-G\frac{M_{1}M_{2}}{|\vec{\mathrm{r}}_{12}|}\right)_{\mathrm{f}}$$

\Uginitial

expression for initial gravitational potential energy
\Uginitial

\Ugfinal

$$\left(-G\frac{M_{1}M_{2}}{|\vec{\mathrm{r}}_{12}|}\right)_{\mathrm{f}}$$

\Uefinal

expression for final electric potential energy
\Uefinal

```
\Uefinal
```

$$\left(\frac{1}{4\pi\epsilon_{_{o}}}\frac{Q_{_{1}}Q_{_{2}}}{|\vec{r}_{_{12}}|}\right)_{_{f}}$$

\Ueinitial

expression for initial electric potential energy
\Ueinitial

```
\Uefinal
```

$$\left(\frac{1}{4\pi\epsilon_{_{o}}}\frac{Q_{_{1}}Q_{_{2}}}{|\vec{r}_{_{12}}|}\right)_{_{f}}$$

\ks

symbol for spring stiffness
\ks

```
\ks
```

$k_{_{s}}$

\Fnet
\Fnetext
\Fnetsys
\Fsub

various symbols for net force
\Fnet or \Fnetext or \Fnetsys or \Fsub{⟨*label*⟩}

```
\Fnet or \Fnetext or \Fnetsys or \Fsub{ball,bat}
```

$\vec{F}_{_{net}}$ or $\vec{F}_{_{net,ext}}$ or $\vec{F}_{_{net,sys}}$ or $\vec{F}_{_{ball,bat}}$

\Tnet
\Tnetext
\Tnetsys
\Tsub

various symbols for net torque
\Tnet or \Tnetext or \Tnetsys or \Tsub{⟨*label*⟩}

```
\Tnet or \Tnetext or \Tnetsys or \Tsub{ball,bat}
```

$\vec{T}_{_{net}}$ or $\vec{T}_{_{net,ext}}$ or $\vec{T}_{_{net,sys}}$ or $\vec{T}_{_{ball,bat}}$

`\vpythonline`

single line of VPython code used inline
`\vpythonline{`⟨*vpythoncode*⟩`}`

```
\vpythonline{from visual import *}
```

from visual **import** ∗

`vpythonblock`

environment for a block of VPython code
`\begin{vpythonblock}`
⟨*vpythoncode*⟩
`\end{vpythonblock}`

```
\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}
```

```
1  from visual import *
2  sphere(center=pos(1,2,3),color=color.green)
3  MyArrow=arrow(pos=earth.pos, axis=fscale*Fnet, color=color
       .green)
4  print ("arrow.pos = "), arrow.pos
```

\vpythonfile

file in the current directory containing VPython code
\vpythonfile⟨*filename*⟩

```
\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`

empty space for filling answer boxes so there is nothing to see
`\emptyanswer[`⟨*wdth*⟩`][`⟨*hght*⟩`]`

```
\emptyanswer[0.75][0.2]
```

`activityanswer`

main environment for typesetting boxed answers
`\begin{activityanswer}[`⟨*bgclr*⟩`][`⟨*frmclr*⟩`][`⟨*txtclr*⟩`][`⟨*wdth*⟩`][`⟨*hght*⟩`]`
⟨*content*⟩
`\end{activityanswer}`

```
\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.

adjactivityanswer

like \activityanswer but adjusts vertically to tightly surround text
\begin{adjactivityanswer} [⟨bgclr⟩] [⟨frmclr⟩] [⟨txtclr⟩] [⟨wdth⟩] [⟨hght⟩] ⟨content⟩ \end{adjactivityanswer}

```
\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

provides a fixed-size box with optional text
\emptybox [⟨txt⟩] [⟨bgclr⟩] [⟨frmclr⟩] [⟨txtclr⟩] [⟨wdth⟩] [⟨hght⟩]

```
\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

like \emptybox but adjusts vertically to tightly surround text
\adjemptybox[⟨*txt*⟩][⟨*bgclr*⟩][⟨*frmclr*⟩][⟨*txtclr*⟩][⟨*wdth*⟩][⟨*hght*⟩]

```
\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

wrapper for \emptybox
\answerbox[⟨*txt*⟩][⟨*bgclr*⟩][⟨*frmclr*⟩][⟨*txtclr*⟩][⟨*wdth*⟩][⟨*hght*⟩]

```
\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

wrapper for \adjemptybox
\adjanswerbox[⟨*txt*⟩][⟨*bgclr*⟩][⟨*frmclr*⟩][⟨*txtclr*⟩][⟨*wdth*⟩][⟨*hght*⟩]

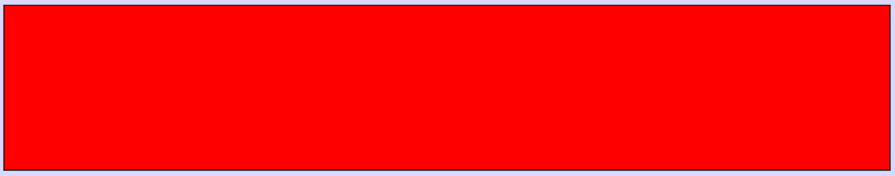
```
\adjanswerbox[Lorem ipsum dolor sit amet, consectetuer adipiscing
elit. Morbi commodo, ipsum sed pharetra gravida, orci magna rhoncus
neque, id pulvinar odio lorem non turpis. Nullam sit amet enim.]
```

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`

answer box with height 0.10 that of current `\textheight` and width 0.90 that of current `\linewidth`
`\smallanswerbox[`⟨*txt*⟩`][`⟨*bgclr*⟩`]`

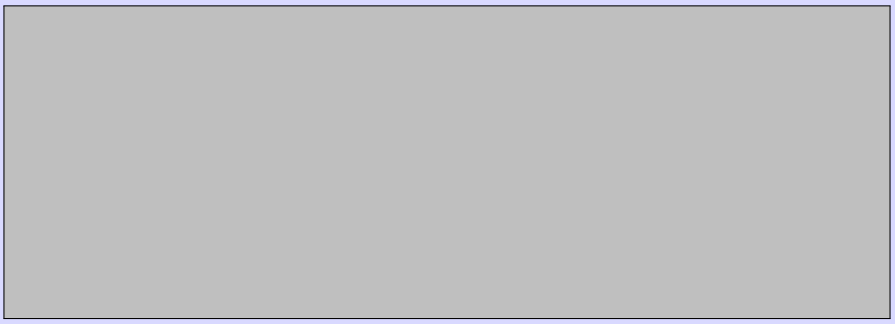
```
\smallanswerbox[][red]
```



`\mediumanswerbox`

answer box with height 0.20 that of current `\textheight` and width 0.90 that of current `\linewidth`
`\mediumanswerbox[`⟨*txt*⟩`][`⟨*bgclr*⟩`]`

```
\mediumanswerbox[][lightgray]
```



`\largeanswerbox`

answer box with height 0.25 that of current `\textheight` and width 0.90 that of current `\linewidth` (too large to show here)
`\largeanswerbox[`⟨*txt*⟩`][`⟨*bgclr*⟩`]`

```
\largeanswerbox[][lightgray]
```

`\largeranswerbox`

answer box with height 0.33 that of current `\textheight` and width 0.90 that of current `\linewidth` (too large to show here)
`\largreanswerbox[`⟨*txt*⟩`][`⟨*bgclr*⟩`]`

```
\largreanswerbox[][lightgray]
```

`\hugeanswerbox`

answer box with height 0.50 that of current `\textheight` and width 0.90 that of current `\linewidth` (too large to show here)
`\hugeanswerbox[`⟨*txt*⟩`][`⟨*bgclr*⟩`]`

```
\hugeanswerbox[][lightgray]
```

`\hugeranswerbox`

answer box with height 0.75 that of current `\textheight` and width 0.90 that of current `\linewidth` (too large to show here)
`\hugeranswerbox[`⟨*txt*⟩`][`⟨*bgclr*⟩`]`

```
\hugeranswerbox[][lightgray]
```

`\fullpageanswerbox`

answer box with height 1.00 that of current `\textheight` and width 0.90 that of current `\linewidth` (too large to show here)
`\fullpageanswerbox[`⟨*txt*⟩`][`⟨*bgclr*⟩`]`

```
\fullpageanswerbox[][lightgray]
```

miinstructornote

environment for highlighting notes to instructors

\begin{miinstructornote}
⟨*content*⟩
\end{miinstructornote}

```
\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.

`mistudentnote`

environment for highlighting notes to students
`\begin{studentnote}`
⟨*content*⟩
`\end{studentnote}`

```
\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.

`miderivation`

fancy environment for mathematical derivations based on `align` environment

`\begin{miderivation}`
⟨*content*⟩
`\end{miderivation}`

```
\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

$$\gamma = \frac{1}{\sqrt{1-\left(\frac{|\vec{v}|}{c}\right)^2}} \qquad \text{given} \qquad (1)$$

$$\gamma^2 = \frac{1}{1-\left(\frac{|\vec{v}|}{c}\right)^2} \qquad \text{square both sides} \qquad (2)$$

$$\frac{1}{\gamma^2} = 1-\left(\frac{|\vec{v}|}{c}\right)^2 \qquad \text{reciprocal of both sides} \qquad (3)$$

$$\left(\frac{|\vec{v}|}{c}\right)^2 = 1-\frac{1}{\gamma^2} \qquad \text{rearrange} \qquad (4)$$

$$\frac{|\vec{v}|}{c} = \sqrt{1-\frac{1}{\gamma^2}} \qquad \text{square root of both sides} \qquad (5)$$

`bwinstructornote`

environment for highlighting notes to instructors

`\begin{bwinstructornote}`
⟨*content*⟩
`\end{bwinstructornote}`

```
\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.

`bwstudentnote`

environment for highlighting notes to students

`\begin{bwstudentnote}`
⟨*content*⟩
`\end{bwstudentnote}`

```
\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.

bwderivation

fancy environment for mathematical derivations based on `align` environment

```
\begin{bwderivation}
⟨content⟩
\end{bwderivation}
```

```
\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

$$\gamma = \frac{1}{\sqrt{1-\left(\frac{|\vec{\mathrm{v}}|}{c}\right)^2}} \qquad \text{given} \qquad (1)$$

$$\gamma^2 = \frac{1}{1-\left(\frac{|\vec{\mathrm{v}}|}{c}\right)^2} \qquad \text{square both sides} \qquad (2)$$

$$\frac{1}{\gamma^2} = 1-\left(\frac{|\vec{\mathrm{v}}|}{c}\right)^2 \qquad \text{reciprocal of both sides} \qquad (3)$$

$$\left(\frac{|\vec{\mathrm{v}}|}{c}\right)^2 = 1-\frac{1}{\gamma^2} \qquad \text{rearrange} \qquad (4)$$

$$\frac{|\vec{\mathrm{v}}|}{c} = \sqrt{1-\frac{1}{\gamma^2}} \qquad \text{square root of both sides} \qquad (5)$$

5.16 Miscellaneous Commands

`\checkpoint`

centered checkpoint for student discussion
`\checkpoint`

```
\checkpoint
```

|——— CHECKPOINT ———|

`\image`

centered figure displayed actual size with caption
`\image{`⟨*imagefilename*⟩`}{`⟨*caption*⟩`}`

```
\image{satellite.pdf}{Photograph of satellite}
```

`\sneakyone`

shows factors dividing to a sneaky one
`\sneakyone{`⟨*thing*⟩`}`

```
\sneakyone{\m}
```

$\not{\mathrm{m}}^{1}$

5.17 Experimental Commands

Should the subscript or component come first?

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}`	$\vec{\mathrm{E}}$	`\vect{E}`
`\vecto{E}[ball]`	$\vec{\mathrm{E}}_{\mathrm{ball}}$	`\vectsub{E}{ball}`
`\compvecto{E}{y}`	E_{y}	`\compvect{E}{y}`
`\compvecto{E}[ball]{x}`	$\mathrm{E}_{\mathrm{ball},x}$	`\compvectsub{E}{ball}{x}`
`\scompsvecto{E}`	$\left\langle \mathrm{E}_{x}, \mathrm{E}_{y}, \mathrm{E}_{z} \right\rangle$	`\scompsvect{E}`
`\scompsvecto{E}[ball]`	$\left\langle \mathrm{E}_{\mathrm{ball},x}, \mathrm{E}_{\mathrm{ball},y}, \mathrm{E}_{\mathrm{ball},z} \right\rangle$	`\scompsvectsub{E}{ball}`
`\compposo{y}`	y	`\comppos{y}`
`\compposo[ball]{y}`	y_{ball}	`\comppossub{ball}{y}`
`\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[intlimits]{amsmath}
\RequirePackage{amssymb}
\RequirePackage{bigints}
\RequirePackage{cancel}
\RequirePackage[leftbars,color]{changebar}
\RequirePackage[dvipsnames]{xcolor}
\RequirePackage{environ}
\RequirePackage{etoolbox}
\RequirePackage{extarrows}
\RequirePackage{filehook}
\RequirePackage[T1]{fontenc}
\RequirePackage{graphicx}
\RequirePackage{epstopdf}
\RequirePackage{textcomp}
\RequirePackage{letltxmacro}
\RequirePackage{listings}
\RequirePackage[framemethod=TikZ]{mdframed}
\RequirePackage[amssymb,cdot,derivedinbase,derived,thickqspace]{SIunits}
\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}}
\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 corrects conflicts with SIunits.

```
\AtBeginOfPackageFile*{SIunits}{%
\csundef{power}
  \csundef{square}
  \newcommand*{\square}[1]{\ensuremath{\mathrm{#1}^{2}}}
  \renewcommand*{\squared}{\ensuremath{^{\mathrm{2}}}}
  \renewcommand*{\cubic}[1]{\ensuremath{\mathrm{#1}^{3}}}
  \renewcommand*{\cubed}{\ensuremath{^{\mathrm{3}}}}
\renewcommand*{\fourth}[1]{\ensuremath{\mathrm{#1}^{4}}}
\renewcommand*{\reciprocal}[1]{\ensuremath{\mathrm{#1}^{\SIminus1}}}
\renewcommand*{\rp}{\ensuremath{^{\mathrm{\SIminus1}}}}
\renewcommand*{\rpsquare}[1]{\ensuremath{\mathrm{#1}^{\SIminus2}}}
\renewcommand*{\rpsquared}{\ensuremath{^{\mathrm{\SIminus2}}}}
\renewcommand*{\rpcubic}[1]{\ensuremath{\mathrm{#1}^{\SIminus3}}}
\renewcommand*{\rpcubed}{\ensuremath{^{\mathrm{\SIminus3}}}}
\renewcommand*{\rpfourth}[1]{\ensuremath{\mathrm{#1}^{\SIminus4}}}
\typeout{mandi: SIunits conflicts fixed, but don't use \protect\square\space.}
}%
```

\newphysicsquantity
\newphysicsconstant
\hereusebaseunit
\hereusedrvdunit
\hereusetradunit
\usebaseunit
\usedrvdunit
\usetradunit
\perpusebaseunit
\perpusedrvdunit
\perpusetradunit

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.}
```

`\m` SI base unit of length or spatial displacement

```
\newcommand{\m}{\metre}
```

`\kg` SI base unit of mass

```
\newcommand{\kg}{\kilogram}
```

`\s` SI base unit of time or temporal displacement

```
\newcommand{\s}{\second}
```

`\A` SI base unit of electric current

```
\newcommand{\A}{\ampere}
```

`\K` SI base unit of thermodynamic temperature

```
\newcommand{\K}{\kelvin}
```

`\mol` SI base unit of amount

```
\newcommand{\mol}{\mole}
```

`\cd` SI base unit of luminous intensity

```
\newcommand{\cd}{\candela}
```

`\displacement`

```
\newphysicsquantity{displacement}{\m}[\m][\m]
```

`\mass`

```
\newphysicsquantity{mass}{\kg}[\kg][\kg]
```

`\duration`

```
\newphysicsquantity{duration}{\s}[\s][\s]
```

`\current`

```
\newphysicsquantity{current}{\A}[\A][\A]
```

```
\temperature
                \newphysicsquantity{temperature}{\K}[\K][\K]

     \amount
                \newphysicsquantity{amount}{\mol}[\mol][\mol]

    \luminous
                \newphysicsquantity{luminous}{\cd}[\cd][\cd]

  \planeangle
                \newphysicsquantity{planeangle}{\m\usk\reciprocal\m}[\radian][\radian]

  \solidangle
                \newphysicsquantity{solidangle}{\m\squared\usk\rpsquare\m}[\steradian][\steradian]

   \indegrees
                \newcommand{\indegrees}[1]{\ensuremath{\unit{#1}{\degree}}}

\inarcminutes
                \newcommand{\inarcminutes}[1]{\ensuremath{\unit{#1}{\arcminute}}}

\inarcseconds
                \newcommand{\inarcseconds}[1]{\ensuremath{\unit{#1}{\arcsecond}}}

        \ineV
                \newcommand{\ineV}[1]{\ensuremath{\unit{#1}{\electronvolt}}}

        \inAU
                \newcommand{\inAU}[1]{\ensuremath{\unit{#1}{AU}}}

   \velocityc
                \newcommand{\velocityc}[1]{\ensuremath{#1c}}

    \velocity
                \newphysicsquantity{velocity}{\m\usk\reciprocal\s}[\m\usk\reciprocal\s][\m\per\s]

\acceleration
                \newphysicsquantity{acceleration}{\m\usk\s\rpsquared}[\newton\per\kg][\m\per\s\squared]

      \gamman
                \newcommand{\gamman}[1]{\ensuremath{#1}}

    \momentum
                \newphysicsquantity{momentum}{\m\usk\kg\usk\reciprocal\s}[\newton\usk\s][\kg\usk\m\per\s]

     \impulse
                \newphysicsquantity{impulse}{\m\usk\kg\usk\reciprocal\s}[\newton\usk\s][\kg\usk\m\per\s]
```

```
            \force
                        \newphysicsquantity{force}{\m\usk\kg\usk\s\rpsquared}[\newton][\newton]

    \springstiffness
                        \newphysicsquantity{springstiffness}{\kg\usk\s\rpsquared}[\newton\per\m][\newton\per\m]

      \springstretch
                        \newphysicsquantity{springstretch}{\m}

             \area
                        \newphysicsquantity{area}{\m\squared}

           \volume
                        \newphysicsquantity{volume}{\cubic\m}

  \linearmassdensity
                        \newphysicsquantity{linearmassdensity}{\reciprocal\m\usk\kg}[\kg\per\m][\kg\per\m]

    \areamassdensity
                        \newphysicsquantity{areamassdensity}{\m\rpsquared\usk\kg}[\kg\per\m\squared]
                        [\kg\per\m\squared]

  \volumemassdensity
                        \newphysicsquantity{volumemassdensity}{\m\rpcubed\usk\kg}[\kg\per\m\cubed]
                        [\kg\per\m\cubed]

      \youngsmodulus
                        \newphysicsquantity{youngsmodulus}{\reciprocal\m\usk\kg\usk\s\rpsquared}
                        [\newton\per\m\squared][\pascal]

             \work
                        \newphysicsquantity{work}{\m\squared\usk\kilogram\usk\s\rpsquared}[\joule]
                        [\newton\usk\m]

           \energy
                        \newphysicsquantity{energy}{\m\squared\usk\kilogram\usk\s\rpsquared}[\joule]
                        [\newton\usk\m]

            \power
                        \newphysicsquantity{power}{\m\squared\usk\kg\usk\s\rpcubed}[\watt][\joule\per\s]

    \angularvelocity
                        \newphysicsquantity{angularvelocity}{\radian\usk\reciprocal\s}[\radian\per\s]
                        [\radian\per\s]

\angularacceleration
                        \newphysicsquantity{angularacceleration}{\radian\usk\s\rpsquared}[\radian\per\s\squared]
                        [\radian\per\s\squared]
```

```
\angularmomentum
                \newphysicsquantity{angularmomentum}{\m\squared\usk\kg\usk\reciprocal\s}[\joule\usk\s]
                [\kg\usk\m\squared\per\s]

\momentofinertia
                \newphysicsquantity{momentofinertia}{\m\squared\usk\kg}[\joule\usk\s\squared]
                [\kg\usk\m\squared]

      \torque
                \newphysicsquantity{torque}{\m\squared\usk\kg\usk\s\rpsquared}[\joule\per\radian]
                [\newton\usk\m]

     \entropy
                \newphysicsquantity{entropy}{\m\squared\usk\kilogram\usk\s\rpsquared\usk\reciprocal\K}
                [\joule\per\K][\joule\per\K]

   \wavelength
                \newphysicsquantity{wavelength}{\m}[\m][\m]

   \wavenumber
                \newphysicsquantity{wavenumber}{\reciprocal\m}[\per\m][\per\m]

    \frequency
                \newphysicsquantity{frequency}{\reciprocal\s}[\hertz][\hertz]

\angularfrequency
                \newphysicsquantity{angularfrequency}{\radian\usk\reciprocal\s}[\radian\per\s]
                [\radian\per\s]

      \charge
                \newphysicsquantity{charge}{\A\usk\s}[\coulomb][\coulomb]

  \permittivity
                \newphysicsquantity{permittivity}{\m\rpcubed\usk\reciprocal\kg\usk\s^{4}\usk\A\squared}
                [\farad\per\m][\coulomb\squared\per\newton\usk\m\squared]

  \permeability
                \newphysicsquantity{permeability}{\m\usk\kg\usk\s\rpsquared\usk\A\rpsquared}
                [\henry\per\m][\tesla\usk\m\per\A]

\electricfield
                \newphysicsquantity{electricfield}{\m\usk\kg\usk\s\rpcubed\usk\reciprocal\A}[\volt\per\m]
                [\newton\per\coulomb]

\electricdipolemom
                \newphysicsquantity{electricdipolemom}{\m\usk\s\usk\A}[\coulomb\usk\m][\coulomb\usk\m]
```

\magneticfield

```
\newphysicsquantity{magneticfield}{\kg\usk\s\rpsquared\usk\reciprocal\A}[\tesla]
[\newton\per\coulomb\usk(\m\per\s)]
```

\cmagneticfield

```
\newphysicsquantity{cmagneticfield}{\m\usk\kg\usk\s\rpcubed\usk\reciprocal\A}[\volt\per\m]
[\newton\per\coulomb]
```

\lv
\rv

```
\newcommand{\lv}{\ensuremath{\left\langle}}
\newcommand{\rv}{\ensuremath{\right\rangle}}
```

\symvect

```
\newcommand{\symvect}{\mivector}
```

\ncompsvect

```
\newcommand{\ncompsvect}{\mivector}
```

\magvectncomps Written in LaTeX3

```
\ExplSyntaxOn
\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
```

\zerovect
\ncompszerovect

```
\newcommand{\zerovect}{\vect{0}}
\newcommand{\ncompszerovect}{\mivector{0,0,0}}
```

```
\vect
        \ifthenelse{\boolean{@optitalicvectors}}
          {\newcommand{\vect}[1]{\ensuremath{\vec{#1}}}}
          {\newcommand{\vect}[1]{\ensuremath{\vec{\mathrm{#1}}}}}

\magvect
        \ifthenelse{\boolean{@optdoubleabsbars}}
          {\newcommand{\magvect}[1]{\ensuremath{\magof{\vect{#1}}}}}
          {\newcommand{\magvect}[1]{\ensuremath{\abs{\vect{#1}}}}}

\dmagvect
\Dmagvect \newcommand{\dmagvect}[1]{\ensuremath{\dx{\magvect{#1}}}}
          \newcommand{\Dmagvect}[1]{\ensuremath{\Delta\!\magvect{#1}}}

\dirvect
        \ifthenelse{\boolean{@optitalicvectors}}
          {\newcommand{\dirvect}[1]{\ensuremath{\widehat{{#1}}}}}
          {\newcommand{\dirvect}[1]{\ensuremath{\widehat{\mathrm{#1}}}}}

\compvect
        \ifthenelse{\boolean{@optitalicvectors}}
          {\newcommand{\compvect}[2]{\ensuremath{\ssub{#1}{\(#2\)}}}}
          {\newcommand{\compvect}[2]{\ensuremath{\ssub{\mathrm{#1}}{\(#2\)}}}}

\scompsvect
        \newcommand{\scompsvect}[1]{\ensuremath{\lv
          \compvect{#1}{x},
          \compvect{#1}{y},
          \compvect{#1}{z}\rv}}

\magvectscomps
        \newcommand{\magvectscomps}[1]{\ensuremath{\sqrt{
          \msup{\compvect{#1}{x}}{2}+
          \msup{\compvect{#1}{y}}{2}+
          \msup{\compvect{#1}{z}}{2}}}}

\dvect
\Dvect  \newcommand{\dvect}[1]{\ensuremath{\mathrm{d}\vect{#1}}}
        \newcommand{\Dvect}[1]{\ensuremath{\Delta\vect{#1}}}

\dirdvect
\dirDvect \newcommand{\dirdvect}[1]{\ensuremath{\widehat{\dvect{#1}}}}
          \newcommand{\dirDvect}[1]{\ensuremath{\widehat{\Dvect{#1}}}}

\ddirvect
\Ddirvect \newcommand{\ddirvect}[1]{\ensuremath{\mathrm{d}\dirvect{E}}}
          \newcommand{\Ddirvect}[1]{\ensuremath{\Delta\dirvect{E}}}
```

```
\magdvect
\magDvect   \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}}}}}

\compdvect
\compDvect  \newcommand{\compdvect}[2]{\ensuremath{\mathrm{d}\compvect{#1}{#2}}}
            \newcommand{\compDvect}[2]{\ensuremath{\Delta\compvect{#1}{#2}}}

\scompsdvect
\scompsDvect  \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}}

\dervect
\Dervect    \newcommand{\dervect}[2]{\ensuremath{\frac{\dvect{#1}}{\mathrm{d}{#2}}}}
            \newcommand{\Dervect}[2]{\ensuremath{\frac{\Dvect{#1}}{\Delta{#2}}}}

\compdervect
\compDervect  \newcommand{\compdervect}[3]{\ensuremath{\dbyd{\compvect{#1}{#3}}{#2}}}
              \newcommand{\compDervect}[3]{\ensuremath{\DbyD{\compvect{#1}{#3}}{#2}}}

\scompsdervect
\scompsDervect  \newcommand{\scompsdervect}[2]{\ensuremath{\lv
                  \compdervect{#1}{#2}{x},
                  \compdervect{#1}{#2}{y},
                  \compdervect{#1}{#2}{z}\rv}}
                \newcommand{\scompsDervect}[2]{\ensuremath{\lv
                  \compDervect{#1}{#2}{x},
                  \compDervect{#1}{#2}{y},
                  \compDervect{#1}{#2}{z}\rv}}

\magdervect
\magDervect  \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}}}}}

\dermagvect
\Dermagvect  \newcommand{\dermagvect}[2]{\ensuremath{\dbyd{\magvect{#1}}{#2}}}
             \newcommand{\Dermagvect}[2]{\ensuremath{\DbyD{\magvect{#1}}{#2}}}
```

```
\scompspos
                \newcommand{\scompspos}{\mivector{x,y,z}}

  \comppos
                \newcommand{\comppos}[1]{\ensuremath{{#1}}}

\scompsdpos
\scompsDpos     \newcommand{\scompsdpos}{\mivector{\mathrm{d}x,\mathrm{d}y,\mathrm{d}z}}
                \newcommand{\scompsDpos}{\mivector{\Delta x,\Delta y,\Delta z}}

  \compdpos
  \compDpos     \newcommand{\compdpos}[1]{\ensuremath{\mathrm{d}{#1}}}
                \newcommand{\compDpos}[1]{\ensuremath{\Delta{#1}}}

\scompsderpos
\scompsDerpos   \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}}

  \compderpos
  \compDerpos   \newcommand{\compderpos}[2]{\ensuremath{\frac{\mathrm{d}{#1}}{\mathrm{d}{#2}}}}
                \newcommand{\compDerpos}[2]{\ensuremath{\frac{\Delta{#1}}{\Delta{#2}}}}

    \vectsub
                \newcommand{\vectsub}[2]{\ensuremath{\ssub{\vect{#1}}{#2}}}

 \compvectsub
                \ifthenelse{\boolean{@optitalicvectors}}
                  {\newcommand{\compvectsub}[3]{\ensuremath{\ssub{#1}{#2,\(#3\)}}}}
                  {\newcommand{\compvectsub}[3]{\ensuremath{\ssub{\mathrm{#1}}{#2,\(#3\)}}}}

\scompsvectsub
                \newcommand{\scompsvectsub}[2]{\ensuremath{\lv
                  \compvectsub{#1}{#2}{x},
                  \compvectsub{#1}{#2}{y},
                  \compvectsub{#1}{#2}{z}\rv}}

  \magvectsub
                \ifthenelse{\boolean{@optdoubleabsbars}}
                  {\newcommand{\magvectsub}[2]{\ensuremath{\magof{\vectsub{#1}{#2}}}}}
                  {\newcommand{\magvectsub}[2]{\ensuremath{\abs{\vectsub{#1}{#2}}}}}

\magvectsubscomps
                \newcommand{\magvectsubscomps}[2]{\ensuremath{\sqrt{
                    \msup{\compvectsub{#1}{#2}{x}}{2}+
                    \msup{\compvectsub{#1}{#2}{y}}{2}+
                    \msup{\compvectsub{#1}{#2}{z}}{2}}}}
```

```
\dirvectsub
                \ifthenelse{\boolean{@optitalicvectors}}
                  {\newcommand{\dirvectsub}[2]{\ensuremath{\ssub{\widehat{#1}}{#2}}}}
                  {\newcommand{\dirvectsub}[2]{\ensuremath{\ssub{\widehat{\mathrm{#1}}}{#2}}}}

  \dvectsub
  \Dvectsub     \newcommand{\dvectsub}[2]{\ensuremath{\mathrm{d}\vectsub{#1}{#2}}}
                \newcommand{\Dvectsub}[2]{\ensuremath{\Delta\vectsub{#1}{#2}}}

\compdvectsub
\compDvectsub   \newcommand{\compdvectsub}[3]{\ensuremath{\mathrm{d}\compvectsub{#1}{#2}{#3}}}
                \newcommand{\compDvectsub}[3]{\ensuremath{\Delta\compvectsub{#1}{#2}{#3}}}

\scompsdvectsub
\scompsDvectsub \newcommand{\scompsdvectsub}[2]{\ensuremath{\lv
                  \compdvectsub{#1}{#2}{x},
                  \compdvectsub{#1}{#2}{y},
                  \compdvectsub{#1}{#2}{z}\rv}}
                \newcommand{\scompsDvectsub}[2]{\ensuremath{\lv
                  \compDvectsub{#1}{#2}{x},
                  \compDvectsub{#1}{#2}{y},
                  \compDvectsub{#1}{#2}{z},\rv}}

\dermagvectsub
\Dermagvectsub  \newcommand{\dermagvectsub}[3]{\ensuremath{\dbyd{\magvectsub{#1}{#2}}{#3}}}
                \newcommand{\Dermagvectsub}[3]{\ensuremath{\DbyD{\magvectsub{#1}{#2}}{#3}}}

  \dervectsub
  \Dervectsub   \newcommand{\dervectsub}[3]{\ensuremath{\dbyd{\vectsub{#1}{#2}}{#3}}}
                \newcommand{\Dervectsub}[3]{\ensuremath{\DbyD{\vectsub{#1}{#2}}{#3}}}

\magdervectsub
\magDervectsub  \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}}}}}

\compdervectsub
\compDervectsub \newcommand{\compdervectsub}[4]{\ensuremath{\dbyd{\compvectsub{#1}{#2}{#4}}{#3}}}
                \newcommand{\compDervectsub}[4]{\ensuremath{\DbyD{\compvectsub{#1}{#2}{#4}}{#3}}}

\scompsdervectsub
\scompsDervectsub \newcommand{\scompsdervectsub}[3]{\ensuremath{\lv
                  \compdervectsub{#1}{#2}{#3}{x},
                  \compdervectsub{#1}{#2}{#3}{y},
                  \compdervectsub{#1}{#2}{#3}{z}\rv}}
                \newcommand{\scompsDervectsub}[3]{\ensuremath{\lv
                  \compDervectsub{#1}{#2}{#3}{x},
                  \compDervectsub{#1}{#2}{#3}{y},
                  \compDervectsub{#1}{#2}{#3}{z}\rv}}
```

```
\comppossub
\newcommand{\comppossub}[2]{\ensuremath{\ssub{#2}{#1}}}

\scompspossub
\newcommand{\scompspossub}[1]{\ensuremath{\lv
  \comppossub{#1}{x},
  \comppossub{#1}{y},
  \comppossub{#1}{z}\rv}}

\compdpossub
\compDpossub
\newcommand{\compdpossub}[2]{\ensuremath{\mathrm{d}\comppossub{#1}{#2}}}
\newcommand{\compDpossub}[2]{\ensuremath{\Delta\comppossub{#1}{#2}}}

\scompsdpossub
\scompsDpossub
\newcommand{\scompsdpossub}[1]{\ensuremath{\lv
  \compdpossub{#1}{x},
  \compdpossub{#1}{y},
  \compdpossub{#1}{z}\rv}}
\newcommand{\scompsDpossub}[1]{\ensuremath{\lv
  \compDpossub{#1}{x},
  \compDpossub{#1}{y},
  \compDpossub{#1}{z}\rv}}

\compderpossub
\compDerpossub
\newcommand{\compderpossub}[3]{\ensuremath{\dbyd{\comppossub{#1}{#3}}{#2}}}
\newcommand{\compDerpossub}[3]{\ensuremath{\DbyD{\comppossub{#1}{#3}}{#2}}}

\scompsderpossub
\scompsDerpossub
\newcommand{\scompsderpossub}[2]{\ensuremath{\lv
  \compderpossub{#1}{#2}{x},
  \compderpossub{#1}{#2}{y},
  \compderpossub{#1}{#2}{z}\rv}}
\newcommand{\scompsDerpossub}[2]{\ensuremath{\lv
  \compDerpossub{#1}{#2}{x},
  \compDerpossub{#1}{#2}{y},
  \compDerpossub{#1}{#2}{z}\rv}}

\relpos
\newcommand{\relpos}[1]{\ensuremath{\vectsub{r}{#1}}}

\relvel
\newcommand{\relvel}[1]{\ensuremath{\vectsub{v}{#1}}}

\relmom
\newcommand{\relmom}[1]{\ensuremath{\vectsub{p}{#1}}}

\relfor
\newcommand{\relfor}[1]{\ensuremath{\vectsub{F}{#1}}}
```

```
\vectdotvect
                \newcommand{\vectdotvect}[2]{\ensuremath{{#1}\bullet{#2}}}

\vectdotsvect
                \newcommand{\vectdotsvect}[2]{\ensuremath{\scompsvect{#1}\bullet\scompsvect{#2}}}

\vectdotevect
                \newcommand{\vectdotevect}[2]{\ensuremath{
                  \compvect{#1}{x}\compvect{#2}{x}+
                  \compvect{#1}{y}\compvect{#2}{y}+
                  \compvect{#1}{z}\compvect{#2}{z}}}

\vectdotspos
                \newcommand{\vectdotspos}[1]{\ensuremath{\scompsvect{#1}\bullet\scompspos}}

\vectdotepos
                \newcommand{\vectdotepos}[1]{\ensuremath{
                  \compvect{#1}{x}\comppos{x}+
                  \compvect{#1}{y}\comppos{y}+
                  \compvect{#1}{z}\comppos{z}}}

\vectdotsdvect
\vectdotsDvect  \newcommand{\vectdotsdvect}[2]{\ensuremath{\scompsvect{#1}\bullet\scompsdvect{#2}}}
                \newcommand{\vectdotsDvect}[2]{\ensuremath{\scompsvect{#1}\bullet\scompsDvect{#2}}}

\vectdotedvect
\vectdoteDvect  \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}}}

\vectdotsdpos
\vectdotsDpos   \newcommand{\vectdotsdpos}[1]{\ensuremath{\scompsvect{#1}\bullet\scompsdpos}}
                \newcommand{\vectdotsDpos}[1]{\ensuremath{\scompsvect{#1}\bullet\scompsDpos}}

\vectdotedpos
\vectdoteDpos   \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}}}
```

\vectsubdotsvectsub

```
\newcommand{\vectsubdotsvectsub}[4]{\ensuremath{
  \scompsvectsub{#1}{#2}\bullet\scompsvectsub{#3}{#4}}}
```

\vectsubdotevectsub

```
\newcommand{\vectsubdotevectsub}[4]{\ensuremath{
  \compvectsub{#1}{#2}{x}\compvectsub{#3}{#4}{x}+
  \compvectsub{#1}{#2}{y}\compvectsub{#3}{#4}{y}+
  \compvectsub{#1}{#2}{z}\compvectsub{#3}{#4}{z}}}
```

\vectsubdotsdvectsub
\vectsubdotsDvectsub

```
\newcommand{\vectsubdotsdvectsub}[4]{\ensuremath{
  \scompsvectsub{#1}{#2}\bullet\scompsdvectsub{#3}{#4}}}
\newcommand{\vectsubdotsDvectsub}[4]{\ensuremath{
  \scompsvectsub{#1}{#2}\bullet\scompsDvectsub{#3}{#4}}}
```

\vectsubdotedvectsub
\vectsubdoteDvectsub

```
\newcommand{\vectsubdotedvectsub}[4]{\ensuremath{
  \compvectsub{#1}{#2}{x}\compdvectsub{#3}{#4}{x}+
  \compvectsub{#1}{#2}{y}\compdvectsub{#3}{#4}{y}+
  \compvectsub{#1}{#2}{z}\compdvectsub{#3}{#4}{z}}}
\newcommand{\vectsubdoteDvectsub}[4]{\ensuremath{
  \compvectsub{#1}{#2}{x}\compDvectsub{#3}{#4}{x}+
  \compvectsub{#1}{#2}{y}\compDvectsub{#3}{#4}{y}+
  \compvectsub{#1}{#2}{z}\compDvectsub{#3}{#4}{z}}}
```

\vectsubdotsdvect
\vectsubdotsDvect

```
\newcommand{\vectsubdotsdvect}[3]{\ensuremath{
  \scompsvectsub{#1}{#2}\bullet\scompsdvect{#3}}}
\newcommand{\vectsubdotsDvect}[3]{\ensuremath{
  \scompsvectsub{#1}{#2}\bullet\scompsDvect{#3}}}
```

\vectsubdotedvect
\vectsubdoteDvect

```
\newcommand{\vectsubdotedvect}[3]{\ensuremath{
  \compvectsub{#1}{#2}{x}\compdvect{#3}{x}+
  \compvectsub{#1}{#2}{y}\compdvect{#3}{y}+
  \compvectsub{#1}{#2}{z}\compdvect{#3}{z}}}
\newcommand{\vectsubdoteDvect}[3]{\ensuremath{
  \compvectsub{#1}{#2}{x}\compDvect{#3}{x}+
  \compvectsub{#1}{#2}{y}\compDvect{#3}{y}+
  \compvectsub{#1}{#2}{z}\compDvect{#3}{z}}}
```

\vectsubdotsdpos
\vectsubdotsDpos

```
\newcommand{\vectsubdotsdpos}[2]{\ensuremath{
  \scompsvectsub{#1}{#2}\bullet\scompsdpos}}
\newcommand{\vectsubdotsDpos}[2]{\ensuremath{
  \scompsvectsub{#1}{#2}\bullet\scompsDpos}}
```

\vectsubdotedpos
\vectsubdoteDpos
```
\newcommand{\vectsubdotedpos}[2]{\ensuremath{
  \compvectsub{#1}{#2}{x}\compdpos{x}+
  \compvectsub{#1}{#2}{y}\compdpos{y}+
  \compvectsub{#1}{#2}{z}\compdpos{z}}}
\newcommand{\vectsubdoteDpos}[2]{\ensuremath{
  \compvectsub{#1}{#2}{x}\compDpos{x}+
  \compvectsub{#1}{#2}{y}\compDpos{y}+
  \compvectsub{#1}{#2}{z}\compDpos{z}}}
```

\dervectdotsvect
\Dervectdotsvect
```
\newcommand{\dervectdotsvect}[3]{\ensuremath{
  \scompsdervect{#1}{#2}\bullet\scompsvect{#3}}}
\newcommand{\Dervectdotsvect}[3]{\ensuremath{
  \scompsDervect{#1}{#2}\bullet\scompsvect{#3}}}
```

\dervectdotevect
\Dervectdotevect
```
\newcommand{\dervectdotevect}[3]{\ensuremath{
  \compdervect{#1}{#2}{x}\compvect{#3}{x}+
  \compdervect{#1}{#2}{y}\compvect{#3}{y}+
  \compdervect{#1}{#2}{z}\compvect{#3}{z}}}
\newcommand{\Dervectdotevect}[3]{\ensuremath{
  \compDervect{#1}{#2}{x}\compvect{#3}{x}+
  \compDervect{#1}{#2}{y}\compvect{#3}{y}+
  \compDervect{#1}{#2}{z}\compvect{#3}{z}}}
```

\vectdotsdervect
\vectdotsDervect
```
\newcommand{\vectdotsdervect}[3]{\ensuremath{
  \scompsvect{#1}\bullet\scompsdervect{#2}{#3}}}
\newcommand{\vectdotsDervect}[3]{\ensuremath{
  \scompsvect{#1}\bullet\scompsDervect{#2}{#3}}}
```

\vectdotedervect
\vectdoteDervect
```
\newcommand{\vectdotedervect}[3]{\ensuremath{
  \compvect{#1}{x}\compdervect{#2}{#3}{x}+
  \compvect{#1}{y}\compdervect{#2}{#3}{y}+
  \compvect{#1}{z}\compdervect{#2}{#3}{z}}}
\newcommand{\vectdoteDervect}[3]{\ensuremath{
  \compvect{#1}{x}\compDervect{#2}{#3}{x}+
  \compvect{#1}{y}\compDervect{#2}{#3}{y}+
  \compvect{#1}{z}\compDervect{#2}{#3}{z}}}
```

\dervectdotspos
\Dervectdotspos
```
\newcommand{\dervectdotspos}[2]{\ensuremath{
  \scompsdervect{#1}{#2}\bullet\scompspos}}
\newcommand{\Dervectdotspos}[2]{\ensuremath{
  \scompsDervect{#1}{#2}\bullet\scompspos}}
```

```
\dervectdotepos
\Dervectdotepos   \newcommand{\dervectdotepos}[2]{\ensuremath{
                    \compdervect{#1}{#2}{x}\comppos{x}+
                    \compdervect{#1}{#2}{y}\comppos{y}+
                    \compdervect{#1}{#2}{z}\comppos{z}}}
                  \newcommand{\Dervectdotepos}[2]{\ensuremath{
                    \compDervect{#1}{#2}{x}\comppos{x}+
                    \compDervect{#1}{#2}{y}\comppos{y}+
                    \compDervect{#1}{#2}{z}\comppos{z}}}

\dervectdotsdvect
\DervectdotsDvect  \newcommand{\dervectdotsdvect}[3]{\ensuremath{
                     \scompsdervect{#1}{#2}\bullet\scompsdvect{#3}}}
                   \newcommand{\DervectdotsDvect}[3]{\ensuremath{
                     \scompsDervect{#1}{#2}\bullet\scompsDvect{#3}}}

\dervectdotedvect
\DervectdoteDvect  \newcommand{\dervectdotedvect}[3]{\ensuremath{
                     \compdervect{#1}{#2}{x}\compdvect{#3}{x}+
                     \compdervect{#1}{#2}{y}\compdvect{#3}{y}+
                     \compdervect{#1}{#2}{z}\compdvect{#3}{z}}}
                   \newcommand{\DervectdoteDvect}[3]{\ensuremath{
                     \compDervect{#1}{#2}{x}\compDvect{#3}{x}+
                     \compDervect{#1}{#2}{y}\compDvect{#3}{y}+
                     \compDervect{#1}{#2}{z}\compDvect{#3}{z}}}

\dervectdotsdpos
\DervectdotsDpos   \newcommand{\dervectdotsdpos}[2]{\ensuremath{
                     \scompsdervect{#1}{#2}\bullet\scompsdpos}}
                   \newcommand{\DervectdotsDpos}[2]{\ensuremath{
                     \scompsDervect{#1}{#2}\bullet\scompsDpos}}

\dervectdotedpos
\DervectdoteDpos   \newcommand{\dervectdotedpos}[2]{\ensuremath{
                     \compdervect{#1}{#2}{x}\compdpos{x}+
                     \compdervect{#1}{#2}{y}\compdpos{y}+
                     \compdervect{#1}{#2}{z}\compdpos{z}}}
                   \newcommand{\DervectdoteDpos}[2]{\ensuremath{
                     \compDervect{#1}{#2}{x}\compDpos{x}+
                     \compDervect{#1}{#2}{y}\compDpos{y}+
                     \compDervect{#1}{#2}{z}\compDpos{z}}}

          \ezero
           \eone   \newcommand{\ezero}{\ensuremath{\msub{\mathbf{e}}{0}}}
           \etwo   \newcommand{\eone}{\ensuremath{\msub{\mathbf{e}}{1}}}
         \ethree   \newcommand{\etwo}{\ensuremath{\msub{\mathbf{e}}{2}}}
          \efour   \newcommand{\ethree}{\ensuremath{\msub{\mathbf{e}}{3}}}
             \ek   \newcommand{\efour}{\ensuremath{\msub{\mathbf{e}}{4}}}
              \e   \newcommand{\ek}[1]{\ensuremath{\msub{\mathbf{e}}{#1}}}
                   \newcommand{\e}{\ek}
```

```
\uezero
 \ueone   \newcommand{\uezero}{\ensuremath{\msub{\widehat{\mathbf{e}}}{0}}}
 \uetwo   \newcommand{\ueone}{\ensuremath{\msub{\widehat{\mathbf{e}}}{1}}}
\uethree  \newcommand{\uetwo}{\ensuremath{\msub{\widehat{\mathbf{e}}}{2}}}
 \uefour  \newcommand{\uethree}{\ensuremath{\msub{\widehat{\mathbf{e}}}{3}}}
    \uek  \newcommand{\uefour}{\ensuremath{\msub{\widehat{\mathbf{e}}}{4}}}
     \ue  \newcommand{\uek}[1]{\ensuremath{\msub{\widehat{\mathbf{e}}}{#1}}}
          \newcommand{\ue}{\uek}

\ezerozero
  \eoneone  \newcommand{\ezerozero}{\ek{00}}
  \eonetwo  \newcommand{\eoneone}{\ek{11}}
 \eonethree \newcommand{\eonetwo}{\ek{12}}
  \eonefour \newcommand{\eonethree}{\ek{13}}
  \etwoone  \newcommand{\eonefour}{\ek{14}}
  \etwotwo  \newcommand{\etwoone}{\ek{21}}
 \etwothree \newcommand{\etwotwo}{\ek{22}}
  \etwofour \newcommand{\etwothree}{\ek{23}}
 \ethreeone \newcommand{\etwofour}{\ek{24}}
 \ethreetwo \newcommand{\ethreeone}{\ek{31}}
\ethreethree\newcommand{\ethreetwo}{\ek{32}}
 \ethreefour\newcommand{\ethreethree}{\ek{33}}
  \efourone \newcommand{\ethreefour}{\ek{34}}
  \efourtwo \newcommand{\efourone}{\ek{41}}
 \efourthree\newcommand{\efourtwo}{\ek{42}}
 \efourfour \newcommand{\efourthree}{\ek{43}}
            \newcommand{\efourfour}{\ek{44}}

\euzero
 \euone   \newcommand{\euzero}{\ensuremath{\msup{\mathbf{e}}{0}}}
 \eutwo   \newcommand{\euone}{\ensuremath{\msup{\mathbf{e}}{1}}}
\euthree  \newcommand{\eutwo}{\ensuremath{\msup{\mathbf{e}}{2}}}
 \eufour  \newcommand{\euthree}{\ensuremath{\msup{\mathbf{e}}{3}}}
    \euk  \newcommand{\eufour}{\ensuremath{\msup{\mathbf{e}}{4}}}
     \eu  \newcommand{\euk}[1]{\ensuremath{\msup{\mathbf{e}}{#1}}}
          \newcommand{\eu}{\euk}
```

```
\euzerozero
  \euoneone   \newcommand{\euzerozero}{\euk{00}}
  \euonetwo   \newcommand{\euoneone}{\euk{11}}
\euonethree   \newcommand{\euonetwo}{\euk{12}}
 \euonefour   \newcommand{\euonethree}{\euk{13}}
  \eutwoone   \newcommand{\euonefour}{\euk{14}}
  \eutwotwo   \newcommand{\eutwoone}{\euk{21}}
\eutwothree   \newcommand{\eutwotwo}{\euk{22}}
 \eutwofour   \newcommand{\eutwothree}{\euk{23}}
\euthreeone   \newcommand{\eutwofour}{\euk{24}}
\euthreetwo   \newcommand{\euthreeone}{\euk{31}}
\euthreethree \newcommand{\euthreetwo}{\euk{32}}
\euthreefour  \newcommand{\euthreethree}{\euk{33}}
  \eufourone  \newcommand{\euthreefour}{\euk{34}}
  \eufourtwo  \newcommand{\eufourone}{\euk{41}}
\eufourthree  \newcommand{\eufourtwo}{\euk{42}}
 \eufourfour  \newcommand{\eufourthree}{\euk{43}}
              \newcommand{\eufourfour}{\euk{44}}

      \gzero
       \gone  \newcommand{\gzero}{\ensuremath{\msub{\mathbf{\gamma}}{0}}}
       \gtwo  \newcommand{\gone}{\ensuremath{\msub{\mathbf{\gamma}}{1}}}
     \gthree  \newcommand{\gtwo}{\ensuremath{\msub{\mathbf{\gamma}}{2}}}
      \gfour  \newcommand{\gthree}{\ensuremath{\msub{\mathbf{\gamma}}{3}}}
         \gk  \newcommand{\gfour}{\ensuremath{\msub{\mathbf{\gamma}}{4}}}
          \g  \newcommand{\gk}[1]{\ensuremath{\msub{\mathbf{\gamma}}{#1}}}
              \newcommand{\g}{\gk}

  \gzerozero
    \goneone  \newcommand{\gzerozero}{\gk{00}}
    \gonetwo  \newcommand{\goneone}{\gk{11}}
  \gonethree  \newcommand{\gonetwo}{\gk{12}}
   \gonefour  \newcommand{\gonethree}{\gk{13}}
    \gtwoone  \newcommand{\gonefour}{\gk{14}}
    \gtwotwo  \newcommand{\gtwoone}{\gk{21}}
  \gtwothree  \newcommand{\gtwotwo}{\gk{22}}
   \gtwofour  \newcommand{\gtwothree}{\gk{23}}
  \gthreeone  \newcommand{\gtwofour}{\gk{24}}
  \gthreetwo  \newcommand{\gthreeone}{\gk{31}}
\gthreethree  \newcommand{\gthreetwo}{\gk{32}}
 \gthreefour  \newcommand{\gthreethree}{\gk{33}}
    \gfourone  \newcommand{\gthreefour}{\gk{34}}
    \gfourtwo  \newcommand{\gfourone}{\gk{41}}
  \gfourthree  \newcommand{\gfourtwo}{\gk{42}}
   \gfourfour  \newcommand{\gfourthree}{\gk{43}}
               \newcommand{\gfourfour}{\gk{44}}
```

\guzero
\guone
\gutwo
\guthree
\gufour
\guk
\gu

```
\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}
```

\guzerozero
\guoneone
\guonetwo
\guonethree
\guonefour
\gutwoone
\gutwotwo
\gutwothree
\gutwofour
\guthreeone
\guthreetwo
\guthreethree
\guthreefour
\gufourone
\gufourtwo
\gufourthree
\gufourfour

```
\newcommand{\guzerozero}{\guk{00}}
\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}}
```

\mivector Vectors formated as in M&I, written in LaTeX3

```
\ExplSyntaxOn
\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
```

\colvector Column and row vectors, written in LaTeX3
\rowvector

```
\ExplSyntaxOn
\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
```

\scompscvect

```
\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}}%
  }%
}%
```

\scompsrvect

```
\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}}%
  }%
}%
```

\oofpez Coulomb constant

```
\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]
```

\oofpezcs Coulomb constant (alternate)

```
\newphysicsconstant{oofpezcs}{\ensuremath{\frac{1}{\phantom{_o}4\pi\ssub{\epsilon}{o}
```

```
c^2\phantom{_o}}}}{\scin{-7}}{\m\usk\kg\usk\s\rpsquared\usk\A\rpsquared}[\tesla\usk\m
\squared][\newton\usk\s\squared\per\coulomb\squared]
```

`\epsz` vacuum permittivity

```
\newphysicsconstant{epsz}{\ensuremath{\ssub{\epsilon}{o}}}{\scin[9]{-12}}
{\m\rpcubed\usk\reciprocal\kg\usk\s^{4}\usk\A\squared}[\farad\per\m]
[\coulomb\squared\per\newton\usk\m\squared]
```

`\mzofp` Biot-Savart constant

```
\newphysicsconstant{mzofp}{\ensuremath{\frac{\phantom{_oo}\ssub{\mu}{o}\phantom{_o}}
{4\pi}}}{\scin{-7}}{\m\usk\kg\usk\s\rpsquared\usk\A\rpsquared}[\henry\per\m]
[\tesla\usk\m\per\A]
```

`\muz` vacuum permeability

```
\newphysicsconstant{muz}{\ensuremath{\ssub{\mu}{o}}}{\scin[4\pi]{-7}}
{\m\usk\kg\usk\s\rpsquared\usk\A\rpsquared}[\henry\per\m][\tesla\usk\m\per\A]
```

`\kboltz` Boltzmann constant

```
\newphysicsconstant{kboltz}{\ensuremath{\ssub{k}{B}}}{\scin[1.38]{-23}}
{\kg\usk\m\squared\usk\rpsquare\s\usk\reciprocal\K}[\joule\per\K][\joule\per\K]
```

`\kboltznev` Boltzmann constant (alternate)

```
\newcommand{\kboltznev}{\ensuremath{\scin[8.62]{-5}{\eV\per\K}}}
```

`\stefan` Stefan-Boltzmann constant

```
\newphysicsconstant{stefan}{\ensuremath{\sigma}}{\scin[5.67]{-8}}{\kg\usk\s\rpcubed\usk
\K^{-4}}[\watt\per\m\squared\usk\K^4][\watt\per\m\squared\usk\K^4]
```

`\planck` Planck constant

```
\newphysicsconstant{planck}{\ensuremath{h}}{\scin[6.62]{-34}}
{\m\squared\usk\kg\usk\reciprocal\s}[\joule\usk\s][\kg\usk\m\squared\per\s]
```

`\plancknev` Planck constant (alternate)

```
\newcommand{\plancknev}{\ensuremath{\scin[4.136]{-15}{\eV\usk\s}}}
```

`\planckbar` reduced Planck constant (Dirac constant)

```
\newphysicsconstant{planckbar}{\ensuremath{\hbar}}{\scin[1.05]{-34}}
{\m\squared\usk\kg\usk\reciprocal\s}[\joule\usk\s][\kg\usk\m\squared\per\s]
```

`\planckbarnev` reduced Planck constant (alternate)

```
\newcommand{\planckbarnev}{\ensuremath{\scin[4.136]{-15}{\eV\usk\s}}}
```

`\Navogadro` Avogadro constant

```
\newphysicsconstant{Navogadro}{\ensuremath{\ssub{N}{A}}}{\scin[6.022]{23}}{\reciprocal
\mol}[\reciprocal\mol][\reciprocal\mol]
```

`\bigG` universal gravitational constant

```
\newphysicsconstant{bigG}{\ensuremath{G}}{\scin[6.67]{-11}}
{\m\cubed\usk\reciprocal\kg\usk\s\rpsquared}[\joule\usk\m\per\kg\squared]
[\newton\usk\m\squared\per\kg\squared]
```

`\littleg` gravitational field strength at Earth's surface

```
\newphysicsconstant{littleg}{\ensuremath{g}}{9.80}{\m\usk\s\rpsquared}[\newton\per\kg]
[\m\per\s\squared]
```

`\clight` light's speed

```
\newphysicsconstant{clight}{\ensuremath{c}}{\scin[3.00]{8}}{\m\usk\reciprocal\s}
[\m\usk\reciprocal\s][\m\per\s]
```

`\clightnfn` light's speed (alternate)

```
\newcommand{\clightnfn}{\ensuremath{\unit{1}{ft\per\nano\s}}}
```

`\Ratom` approximate atomic radius

```
\newphysicsconstant{Ratom}{\ensuremath{\ssub{r}{atom}}}{\scin{-10}}{\m}[\m][\m]
```

`\Mproton` proton's mass

```
\newphysicsconstant{Mproton}{\ensuremath{\ssub{m}{proton}}}{\scin[1.673]{-27}}{\kg}
[\kg][\kg]
```

`\Mneutron` neutron's mass

```
\newphysicsconstant{Mneutron}{\ensuremath{\ssub{m}{neutron}}}{\scin[1.675]{-27}}
{\kg}[\kg][\kg]
```

`\Mhydrogen` hydrogen atom's mass

```
\newphysicsconstant{Mhydrogen}{\ensuremath{\ssub{m}{hydrogen}}}{\scin[1.673]{-27}}
{\kg}[\kg][\kg]
```

`\Melectron` electron's mass

```
\newphysicsconstant{Melectron}{\ensuremath{\ssub{m}{electron}}}{\scin[9.109]{-31}}
{\kg}[\kg][\kg]
```

`\echarge` charge quantum

```
\newphysicsconstant{echarge}{\ensuremath{e}}{\scin[1.602]{-19}}{\A\usk\s}[\coulomb]
[\coulomb]
```

`\Qelectron` electron's charge
`\qelectron`

```
\newphysicsconstant{Qelectron}{\ensuremath{\ssub{Q}{electron}}}{-\echargevalue}
{\A\usk\s}[\coulomb][\coulomb]
\newphysicsconstant{qelectron}{\ensuremath{\ssub{q}{electron}}}{-\echargevalue}
{\A\usk\s}[\coulomb][\coulomb]
```

`\Qproton` proton's charge
`\qproton`

```
\newphysicsconstant{Qproton}{\ensuremath{\ssub{Q}{proton}}}{+\echargevalue}
{\A\usk\s}[\coulomb][\coulomb]
\newphysicsconstant{qproton}{\ensuremath{\ssub{q}{proton}}}{+\echargevalue}
{\A\usk\s}[\coulomb][\coulomb]
```

`\MEarth` Earth's mass

```
\newphysicsconstant{MEarth}{\ensuremath{\ssub{M}{Earth}}}{\scin[6]{24}}{\kg}[\kg][\kg]
```

`\MMoon` Moon's mass

```
\newphysicsconstant{MMoon}{\ensuremath{\ssub{M}{Moon}}}{\scin[7]{22}}{\kg}[\kg][\kg]
```

`\MSun` Sun's mass

```
\newphysicsconstant{MSun}{\ensuremath{\ssub{M}{Sun}}}{\scin[2]{30}}{\kg}[\kg][\kg]
```

`\REarth` Earth's radius

```
\newphysicsconstant{REarth}{\ensuremath{\ssub{R}{Earth}}}{\scin[6.4]{6}}{\m}[\m][\m]
```

`\RMoon` Moon's radius

```
\newphysicsconstant{RMoon}{\ensuremath{\ssub{R}{Moon}}}{\scin[1.75]{6}}{\m}[\m][\m]
```

`\RSun` Sun's radius

```
\newphysicsconstant{RSun}{\ensuremath{\ssub{R}{Sun}}}{\scin[7]{8}}{\m}[\m][\m]
```

`\ESdist` `\SEdist` Earth-Sun distance (Sun-Earth distance)

```
\newphysicsconstant{ESdist}{\magvectsub{r}{ES}}{\scin[1.5]{11}}{\m}[\m][\m]
\newphysicsconstant{SEdist}{\magvectsub{r}{SE}}{\scin[1.5]{11}}{\m}[\m][\m]
```

`\EMdist` `\MEdist` Earth-Moon distance (Moon-Earth distance)

```
\newphysicsconstant{EMdist}{\magvectsub{r}{EM}}{\scin[4]{8}}{\m}[\m][\m]
\newphysicsconstant{MEdist}{\magvectsub{r}{ME}}{\scin[4]{8}}{\m}[\m][\m]
```

`\lightyear` `\Lightyear` `\cyear` `\cyr` `\yyear` `\yr` `\parsec` light year, year, and parsec

```
\newcommand{\lightyear}{\ensuremath{\mathrm{ly}}}
\newcommand{\Lightyear}{\ensuremath{\mathrm{LY}}}
\newcommand{\cyear}{\ensuremath{c\usk\mathrm{year}}}
\newcommand{\cyr}{\ensuremath{c\usk\mathrm{yr}}}
\newcommand{\yyear}{\ensuremath{\mathrm{year}}}
\newcommand{\yr}{\ensuremath{\mathrm{yr}}}
\newcommand{\parsec}{\ensuremath{\mathrm{pc}}}
```

`\LSun` Sun's luminosity

```
\newphysicsconstant{LSun}{\ensuremath{\ssub{L}{Sun}}}{\scin[4]{26}}
  {\m\squared\usk\kg\usk\s\rpcubed}[\watt][\joule\per\s]
```

`\TSun` Sun's effective temperature

```
\newphysicsconstant{TSun}{\ensuremath{\ssub{T}{Sun}}}{5800}{\K}[\K][\K]
```

`\MagSun` Sun's absolute magnitude

```
\newphysicsconstant{MagSun}{\ensuremath{\ssub{M}{Sun}}}{+4.83}{}[][]
```

`\magSun` Sun's apparent magnitude

```
\newphysicsconstant{magSun}{\ensuremath{\ssub{m}{Sun}}}{-26.74}{}[][]
```

`\Lstar` `\Lsolar` stellar and solar luminosity

```
\newcommand{\Lstar}[1][\(\star\)]{\ensuremath{\ssub{L}{#1}}}
\newcommand{\Lsolar}{\ensuremath{\Lstar[\(\odot\)]}}
```

\Tstar
\Tsolar

stellar and solar temperature

```
\newcommand{\Tstar}[1][\(\star\)]{\ensuremath{\ssub{T}{#1}}}
\newcommand{\Tsolar}{\ensuremath{\Tstar[\(\odot\)]}}
```

\Rstar
\Rsolar

stellar and solar radius

```
\newcommand{\Rstar}[1][\(\star\)]{\ensuremath{\ssub{R}{#1}}}
\newcommand{\Rsolar}{\ensuremath{\Rstar[\(\odot\)]}}
```

\Mstar
\Msolar

stellar and solar mass

```
\newcommand{\Mstar}[1][\(\star\)]{\ensuremath{\ssub{M}{#1}}}
\newcommand{\Msolar}{\ensuremath{\Mstar[\(\odot\)]}}
```

\Fstar
\fstar
\FSun
\fSun
\Fsolar
\fsolar

stellar and solar fluxes

```
\newcommand{\Fstar}[1][\(\star\)]{\ensuremath{\ssub{F}{#1}}}
\newcommand{\fstar}[1][\(\star\)]{\ensuremath{\ssub{f}{#1}}}
\newcommand{\FSun}{\ensuremath{\Fstar[Sun]}}
\newcommand{\fSun}{\ensuremath{\fstar[Sun]}}
\newcommand{\Fsolar}{\ensuremath{\Fstar[\(\odot\)]}}
\newcommand{\fsolar}{\ensuremath{\fstar[\(\odot\)]}}
```

\Magstar
\magstar
\Magsolar
\magsolar

stellar and solar magnitudes

```
\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[\(\odot\)]}}
```

\Dstar
\dstar
\Dsolar
\dsolar

stellar and solar distance

```
\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[\(\odot\)]}}
```

\onehalf
\onethird
\onefourth
\onefifth
\onesixth
\oneseventh
\oneeighth
\oneninth
\onetenth
\twothirds
\twofifths
\twosevenths
\twoninths
\threehalves
\threefourths
\threefifths
\threesevenths
\threeeighths
\threetenths
\fourthirds

frequently used fractions

```
\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{\twothirds}{\ensuremath{\frac{2}{3}}\xspace}
\newcommand{\twofifths}{\ensuremath{\frac{2}{5}}\xspace}
\newcommand{\twosevenths}{\ensuremath{\frac{2}{7}}\xspace}
\newcommand{\twoninths}{\ensuremath{\frac{2}{9}}\xspace}
\newcommand{\threehalves}{\ensuremath{\frac{3}{2}}\xspace}
\newcommand{\threefourths}{\ensuremath{\frac{3}{4}}\xspace}
\newcommand{\threefifths}{\ensuremath{\frac{3}{5}}\xspace}
```

```
\newcommand{\threesevenths}{\ensuremath{\frac{3}{7}}\xspace}
\newcommand{\threeeighths}{\ensuremath{\frac{3}{8}}\xspace}
\newcommand{\threetenths}{\ensuremath{\frac{3}{10}}\xspace}
\newcommand{\fourthirds}{\ensuremath{\frac{4}{3}}\xspace}
```

`\dx` variable of integration

```
\newcommand{\dx}[1]{\ensuremath{\,\mathrm{d}{#1}}}
```

`\evalfromto`

```
\newcommand{\evalfromto}[3]{\ensuremath{\Bigg.{#1}\Bigg\rvert_{#2}^{#3}}}
```

`\evalat`

```
\newcommand{\evalat}[2]{\ensuremath{\Bigg.{#1}\Bigg\rvert_{#2}}}
```

`\evaluatedat`

```
\newcommand{\evaluatedat}[1]{\ensuremath{\Bigg.\Bigg\rvert_{#1}}}
```

`\integral`
`\Integral`

```
\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}}
```

`\opensurfintegral`
`\opensurfIntegral`

```
\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}}}
```

`\closedsurfintegral`
`\closedsurfIntegral`

```
\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}}}
```

`\openlineintegral`
`\openlineIntegral`

```
\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}}}
```

```
\closedlineintegral
\closedlineIntegral   \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}}}

            \dbydt
            \DbyDt    \newcommandx{\dbydt}[1][1]{\ensuremath{\frac{\mathrm{d}{#1}}{\mathrm{d}t}}}
                      \newcommandx{\DbyDt}[1][1]{\ensuremath{\frac{\Delta{#1}}{\Delta t}}}

           \ddbydt
           \DDbyDt    \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}}}}

            \pbypt
                      \newcommandx{\pbypt}[1][1]{\ensuremath{\frac{\partial{#1}}{\partial t}}}

           \ppbypt
                      \newcommandx{\ppbypt}[1][1]{\ensuremath{\frac{\partial^{2}{#1}}{\partial t^{2}}}}

             \dbyd
             \DbyD    \newcommand{\dbyd}[2]{\ensuremath{\frac{\mathrm{d}{#1}}{\mathrm{d}{#2}}}}
                      \newcommand{\DbyD}[2]{\ensuremath{\frac{\Delta{#1}}{\Delta{#2}}}}

            \ddbyd
            \DDbyD    \newcommand{\ddbyd}[2]{\ensuremath{\frac{\mathrm{d}^{2}{#1}}{\mathrm{d}{#2}^{2}}}}
                      \newcommand{\DDbyD}[2]{\ensuremath{\frac{\Delta^{2}{#1}}{\Delta{#2}^{2}}}}

             \pbyp
                      \newcommand{\pbyp}[2]{\ensuremath{\frac{\partial{#1}}{\partial{#2}}}}

            \ppbyp
                      \newcommand{\ppbyp}[2]{\ensuremath{\frac{\partial^{2}{#1}}{\partial{#2}^{2}}}}

       \seriesfofx
       \seriesexpx    \newcommand{\seriesfofx}{\ensuremath{%
       \seriessinx    f(x) \approx f(a) + \frac{f^\prime (a)}{1!}(x-a) + \frac{f^{\prime\prime}(a)}{2!}(x-a)^2
       \seriescosx    + \frac{f^{\prime\prime\prime}(a)}{3!}(x-a)^3 + \ldots}\xspace}
       \seriestanx    \newcommand{\seriesexpx}{\ensuremath{%
       \seriesatox    e^x \approx 1 + x + \frac{x^2}{2!} + \frac{x^3}{3!} + \ldots}\xspace}
 \serieslnoneplusx    \newcommand{\seriessinx}{\ensuremath{%
   \binomialseries    \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}
```

\divergence user must specify \vect{} around the argument to get arrows

\curl

```
\newcommand{\divergence}[1]{\ensuremath{\vectdotvect{\nabla}{#1}}}
\newcommand{\curl}[1]{\ensuremath{\nabla\times{#1}}}
```

\diracdelta

```
\newcommand{\diracdelta}[1]{\ensuremath{\boldsymbol{\delta}\quant{#1}}}
```

\asin

```
\DeclareMathOperator{\asin}{\sin^{-1}}
```

\acos

```
\DeclareMathOperator{\acos}{\cos^{-1}}
```

\atan

```
\DeclareMathOperator{\atan}{\tan^{-1}}
```

\asec

```
\DeclareMathOperator{\asec}{\sec^{-1}}
```

\acsc

```
\DeclareMathOperator{\acsc}{\csc^{-1}}
```

\acot

```
\DeclareMathOperator{\acot}{\cot^{-1}}
```

\sech

```
\DeclareMathOperator{\sech}{sech}
```

\csch

```
\DeclareMathOperator{\csch}{csch}
```

\asinh

```
\DeclareMathOperator{\asinh}{\sinh^{-1}}
```

\acosh

```
\DeclareMathOperator{\acosh}{\cosh^{-1}}
```

\atanh

```
\DeclareMathOperator{\atanh}{\tanh^{-1}}
```

\asech

```
\DeclareMathOperator{\asech}{\sech^{-1}}
```

```
  \acsch
          \DeclareMathOperator{\acsch}{\csch^{-1}}

  \acoth
          \DeclareMathOperator{\acoth}{\coth^{-1}}

    \sgn
          \DeclareMathOperator{\sgn}{sgn}

    \dex
          \DeclareMathOperator{\dex}{dex}

     \eV
     \ev  \newcommand{\eV}{\electronvolt}
          \newcommand{\ev}{\electronvolt}

    \emf
          \newcommand{\emf}{\ensuremath{\mathrm{emf}}}

   \logb
          \newcommand{\logb}[1][\relax]{\ensuremath{\log_{_{#1}}}}

     \cB
          \ifthenelse{\boolean{@optitalicvectors}}
            {\newcommand{\cB}{\ensuremath{c\mskip -5.00mu B}}}
            {\newcommand{\cB}{\ensuremath{\textsf{c}\mskip -3.00mu\mathrm{B}}}}

  \newpi
          \newcommand{\newpi}{\ensuremath{\pi\mskip -7.8mu\pi}}

\scripty
          \newcommand{\scripty}[1]{\ensuremath{\mathcalligra{#1}}}

   \flux
          \newcommandx{\flux}[1][1]{\ensuremath{\ssub{\Phi}{#1}}}

    \abs
          \newcommand{\abs}[1]{\ensuremath{\left\lvert{#1}\right\rvert}}

  \magof
          \newcommand{\magof}[1]{\ensuremath{\left\lVert{#1}\right\rVert}}

 \dimsof
          \newcommand{\dimsof}[1]{\ensuremath{\left[{#1}\right]}}

\unitsof
          \newcommand{\unitsof}[1]{\ensuremath{\left[{#1}\right]_{_{u}}}}
```

\quant
\bquant
```
\newcommand{\quant}[1]{\ensuremath{\left({#1}\right)}}
\newcommand{\bquant}[1]{\ensuremath{\left[{#1}\right]}}
```

\changein
\Changein
```
\newcommand{\changein}[1]{\ensuremath{\delta{#1}}}
\newcommand{\Changein}[1]{\ensuremath{\Delta{#1}}}
```

\scin
\ee
\EE
```
\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}}}
```

\dms
\hms
\clockreading
```
\newcommand{\dms}[3]{\ensuremath{\indegrees{#1}\inarcminutes{#2}\inarcseconds{#3}}}
\newcommand{\hms}[3]{\ensuremath{{#1}^{\hour}{#2}^{\mathrm{m}}{#3}^{\s}}}
\newcommand{\clockreading}{\hms}
```

\latitude
\latitudeN
\latitudeS
\longitude
\longitudeE
\longitudeW
```
\newcommand{\latitude}[1]{\ensuremath{\unit{#1}{\degree}}}
\newcommand{\latitudeN}[1]{\ensuremath{\unit{#1}{\degree\; N}}}
\newcommand{\latitudeS}[1]{\ensuremath{\unit{#1}{\degree\; S}}}
\newcommand{\longitude}[1]{\ensuremath{\unit{#1}{\degree}}}
\newcommand{\longitudeE}[1]{\ensuremath{\unit{#1}{\degree\; E}}}
\newcommand{\longitudeW}[1]{\ensuremath{\unit{#1}{\degree\; W}}}
```

\ssub 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}}}}}}}
```

\ssup 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}}}}}}}
```

\ssud

```
\newcommand{\ssud}[3]{\ensuremath{{#1}^{^{^{\mbox{\tiny{#2}}}}}_{_{_{\mbox{\tiny{#3}}}}}}}
```

\msub 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}}}}}}
```

\msup 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}}}}}
```

\msud

```
\newcommand{\msud}[3]{\ensuremath{#1^{^{\scriptstyle{#2}}}_{_{_{\scriptstyle{#3}}}}}}
```

\levicivita

```
\newcommand{\levicivita}[1]{\ensuremath{\msub{\varepsilon}{#1}}}
```

\xaxis \yaxis \zaxis \naxis Coordinate axes.

```
\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}}}
```

\xyplane \yzplane \zxplane \yxplane \zyplane \xzplane All permutations of planes formed by cartesian axes.

```
\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 }}}
```

\cuberoot \fourthroot \fifthroot \fsqrt \fcuberoot \ffourthroot \ffifthroot 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}}}
```

\relgamma \frelgamma

```
\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}}}
```

\oosqrtomxs

```
\newcommand{\oosqrtomxs}[1]{\ensuremath{\frac{1}{\sqrt{1-\msup{#1}{2}}}}}
```

\oosqrtomx

```
\newcommand{\oosqrtomx}[1]{\ensuremath{\frac{1}{\sqrt{1-{#1}}}}}
```

\ooomx

```
\newcommand{\ooomx}[1]{\ensuremath{\frac{1}{1-{#1}}}}
```

\ooopx

```
\newcommand{\ooopx}[1]{\ensuremath{\frac{1}{1+{#1}}}}
```

\isequals

```
\newcommand{\isequals}{\wordoperator{?}{=}\xspace}
```

```
\wordoperator
                \newcommand{\wordoperator}[2]{\ensuremath{%
                  \mathrel{\vcenter{\offinterlineskip
                  \halign{\hfil\tiny\upshape##\hfil\cr\noalign{\vskip-.5ex}
                    {#1}\cr\noalign{\vskip.5ex}{#2}\cr}}}}}

    \definedas
   \associated  \newcommand{\definedas}{\wordoperator{defined}{as}\xspace}
   \adjustedby  \newcommand{\associated}{\wordoperator{associated}{with}\xspace}
  \earlierthan  \newcommand{\adjustedby}{\wordoperator{adjusted}{by}\xspace}
    \laterthan  \newcommand{\earlierthan}{\wordoperator{earlier}{than}\xspace}
     \forevery  \newcommand{\laterthan}{\wordoperator{later}{than}\xspace}
                \newcommand{\forevery}{\wordoperator{for}{every}\xspace}

\pwordoperator
                \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)}}%

    \pdefinedas
   \passociated  \newcommand{\pdefinedas}{\pwordoperator{defined}{as}\xspace}
   \padjustedby  \newcommand{\passociated}{\pwordoperator{associated}{with}\xspace}
  \pearlierthan  \newcommand{\padjustedby}{\pwordoperator{adjusted}{by}\xspace}
    \platerthan  \newcommand{\pearlierthan}{\pwordoperator{earlier}{than}\xspace}
     \pforevery  \newcommand{\platerthan}{\pwordoperator{later}{than}\xspace}
                 \newcommand{\pforevery}{\pwordoperator{for}{every}\xspace}

       \defines
                \newcommand{\defines}{\ensuremath{\stackrel{\text{\tiny{def}}}{=}}\xspace}

       \inframe
                \newcommand{\inframe}[1][\relax]{\ensuremath{\xrightarrow[\tiny{\mathcal #1}]{}}\xspace}

    \associates
                \newcommand{\associates}{\ensuremath{\xrightarrow{\text{\tiny{assoc}}}}\xspace}

       \becomes
                \newcommand{\becomes}{\ensuremath{\xrightarrow{\text{\tiny{becomes}}}}\xspace}

    \lrelatedto
    \rrelatedto  \newcommand{\rrelatedto}[1]{\ensuremath{\xLongrightarrow{\text{\tiny{#1}}}}}
    \brelatedto  \newcommand{\lrelatedto}[1]{\ensuremath{\xLongleftarrow[\text{\tiny{#1}}]{}}}
                 \newcommand{\brelatedto}[2]{\ensuremath{
                   \xLongleftrightarrow[\text{\tiny{#1}}]{\text{\tiny{#2}}}}}

   \momprinciple
\LHSmomprinciple  \newcommand{\momprinciple}{\ensuremath{
\RHSmomprinciple    \vectsub{p}{sys,f}=\vectsub{p}{sys,i}+\Fnetsys\Delta t}}
```

```
\newcommand{\LHSmomprinciple}{\ensuremath{
  \vectsub{p}{sys,f}}}
\newcommand{\RHSmomprinciple}{\ensuremath{
  \vectsub{p}{sys,i}+\Fnetsys\Delta t}}
```

```
   \energyprinciple
\LHSenergyprinciple
\RHSenergyprinciple
```

```
\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}}
```

```
  \angularmomprinciple
\LHSangularmomprinciple
\RHSangularmomprinciple
```

```
\newcommand{\angularmomprinciple}{\ensuremath{\vectsub{L}{sys,A,f}=\vectsub{L}{sys,A,i}+
  \Tnetsys\Delta t}}
\newcommand{\LHSangularmomprinciple}{\ensuremath{\vectsub{L}{sys,A,f}}}
\newcommand{\RHSangularmomprinciple}{\ensuremath{\vectsub{L}{sys,A,i}+\Tnetsys\Delta t}}
```

```
      \gravinteraction
```

```
\newcommand{\gravinteraction}{\ensuremath{
  \bigGmathsymbol\frac{\msub{M}{1}\msub{M}{2}}{\msup{\magvectsub{r}{12}}{2}}
  \quant{-\dirvectsub{r}{12}}}}
```

```
      \elecinteraction
```

```
\newcommand{\elecinteraction}{\ensuremath{
  \oofpezmathsymbol\frac{\msub{Q}{1}\msub{Q}{2}}{\msup{\magvectsub{r}{12}}{2}}
  \dirvectsub{r}{12}}}
```

```
    \Bfieldofparticle
```

```
\newcommand{\Bfieldofparticle}{\ensuremath{
  \mzofpmathsymbol\frac{Q\magvect{v}}{\msup{\magvect{r}}{2}}\dirvect{v}\times\dirvect{r}}}
```

```
    \Efieldofparticle
```

```
\newcommand{\Efieldofparticle}{\ensuremath{
  \oofpezmathsymbol\frac{Q}{\msup{\magvect{r}}{2}}\dirvect{r}}}
```

```
            \Esys
```

```
\newcommand{\Esys}{\ssub{E}{sys}}
```

```
              \Us
```

```
\newcommandx{\Us}[1][1]{\ssub{\ssub{U}{s}}{#1}}
```

```
              \Ug
```

```
\newcommandx{\Ug}[1][1]{\ssub{\ssub{U}{g}}{#1}}
```

```
              \Ue
```

```
\newcommandx{\Ue}[1][1]{\ssub{\ssub{U}{e}}{#1}}
```

```
          \Ktrans
```

```
\newcommandx{\Ktrans}[1][1]{\ssub{\ssub{K}{trans}}{#1}}
```

```
      \Krot
                \newcommandx{\Krot}[1][1]{\ssub{\ssub{K}{rot}}{#1}}
 \Eparticle
                \newcommandx{\Eparticle}[1][1]{\ssub{\ssub{E}{particle}}{#1}}
 \Einternal
                \newcommandx{\Einternal}[1][1]{\ssub{\ssub{E}{internal}}{#1}}
     \Erest
                \newcommandx{\Erest}[1][1]{\ssub{\ssub{E}{rest}}{#1}}
     \Echem
                \newcommandx{\Echem}[1][1]{\ssub{\ssub{E}{chem}}{#1}}
    \Etherm
                \newcommandx{\Etherm}[1][1]{\ssub{\ssub{E}{therm}}{#1}}
      \Evib
                \newcommandx{\Evib}[1][1]{\ssub{\ssub{E}{vib}}{#1}}
   \Ephoton
                \newcommandx{\Ephoton}[1][1]{\ssub{\ssub{E}{photon}}{#1}}
     \DEsys
                \newcommand{\DEsys}{\Changein\Esys}
       \DUs
                \newcommand{\DUs}{\Changein\Us}
       \DUg
                \newcommand{\DUg}{\Changein\Ug}
       \DUe
                \newcommand{\DUe}{\Changein\Ue}
   \DKtrans
                \newcommand{\DKtrans}{\Changein\Ktrans}
     \DKrot
                \newcommand{\DKrot}{\Changein\Krot}
\DEparticle
                \newcommand{\DEparticle}{\Changein\Eparticle}
\DEinternal
                \newcommand{\DEinternal}{\Changein\Einternal}
```

```
   \DErest
            \newcommand{\DErest}{\Changein\Erest}

   \DEchem
            \newcommand{\DEchem}{\Changein\Echem}

  \DEtherm
            \newcommand{\DEtherm}{\Changein\Etherm}

    \DEvib
            \newcommand{\DEvib}{\Changein\Evib}

 \DEphoton
            \newcommand{\DEphoton}{\Changein\Ephoton}

  \Usfinal
            \newcommand{\Usfinal}{\ssub{\left(\onehalf\ks \msup{s}{2}\right)}{f}}

\Usinitial
            \newcommand{\Usinitial}{\ssub{\left(\onehalf\ks \msup{s}{2}\right)}{i}}

  \Ugfinal
            \newcommand{\Ugfinal}{\ssub{\left(-G\frac{\msub{M}{1}\msub{M}{2}}
              {\magvectsub{r}{12}}\right)}{f}}

\Uginitial
            \newcommand{\Uginitial}{\ssub{\left(-G\frac{\msub{M}{1}\msub{M}{2}}
              {\magvectsub{r}{12}}\right)}{i}}

  \Uefinal
            \newcommand{\Uefinal}{\ssub{\left(\oofpezmathsymbol\frac{\ssub{Q}{1}\ssub{Q}{2}}
              {\magvectsub{r}{12}}\right)}{f}}

\Ueinitial
            \newcommand{\Ueinitial}{\ssub{\left(\oofpezmathsymbol\frac{\ssub{Q}{1}\ssub{Q}{2}}
              {\magvectsub{r}{12}}\right)}{i}}

      \ks
            \newcommand{\ks}{\ssub{k}{s}}

    \Fnet
 \Fnetext   \newcommand{\Fnet}{\ensuremath{\vectsub{F}{net}}}
 \Fnetsys   \newcommand{\Fnetext}{\ensuremath{\vectsub{F}{net,ext}}}
    \Fsub   \newcommand{\Fnetsys}{\ensuremath{\vectsub{F}{net,sys}}}
            \newcommand{\Fsub}[1]{\ensuremath{\vectsub{F}{#1}}}
```

```
\Tnet
\Tnetext   \newcommand{\Tnet}{\ensuremath{\vectsub{T}{net}}}
\Tnetsys   \newcommand{\Tnetext}{\ensuremath{\vectsub{T}{net,ext}}}
\Tsub      \newcommand{\Tnetsys}{\ensuremath{\vectsub{T}{net,sys}}}
           \newcommand{\Tsub}[1]{\ensuremath{\vectsub{T}{#1}}}

\vpythonline
           \newcommand{\vpythonline}{\lstinline[language=Python,numbers=left,numberstyle=\tiny,
             upquote=true,breaklines]}

vpythonblock
           \lstnewenvironment{vpythonblock}{\lstvpython}{}

\vpythonfile
           \newcommand{\vpythonfile}{\lstinputlisting[language=Python,numbers=left,
             numberstyle=\tiny,upquote=true,breaklines]}

\emptyanswer
           \newcommandx{\emptyanswer}[2][1=0.80,2=0.1,usedefault]
             {\begin{minipage}{#1\textwidth}\hfill\vspace{#2\textheight}\end{minipage}}

activityanswer
           \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}%
           }%

adjactivityanswer
           \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}%
           }%
```

\emptybox

```
\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}}%
```

\adjemptybox

```
\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}}%
```

\answerbox

```
\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]}}%
```

\adjanswerbox

```
\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]}}%
```

\smallanswerbox box that takes up ten percent of text height

```
\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]}}%
```

`\mediumanswerbox` box that takes up twenty percent of text height

```
\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]
    }%
}%
```

`\largeanswerbox` box that takes up twenty-five percent of text height

```
\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]
    }%
}%
```

`\largeranswerbox` box that takes up thirty-three percent of text height

```
\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]
    }%
}%
```

`\hugeanswerbox` box that takes up fifty percent of text height

```
\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]
    }%
}%
```

\hugeranswerbox box that takes up seventy-five percent of text height

```
\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]
    }%
}%
```

\fullpageanswerbox box that takes up one hundred percent of text height

```
\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]}}%
```

miinstructornote

```
\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}
}%
```

mistudentnote

```
\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}
}%
```

miderivation This definition requires the mdframed package.

```
\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}
}%
```

bwinstructornote

```
\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}
}%
```

bwstudentnote

```
\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}
}%
```

bwderivation This definition requires the mdframed package.

```
\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}
}
```

\checkpoint

```
\newcommand{\checkpoint}{%
  \vspace{1cm}\begin{center}|--------- CHECKPOINT ---------|\end{center}}%
```

\image

```
\newcommand{\image}[2]{%
  \begin{figure}[h!]
    \begin{center}%
      \includegraphics[scale=1]{#1}%
      \caption{#2}%
      \label{#1}%
    \end{center}%
  \end{figure}}
```

\sneakyone

```
\newcommand{\sneakyone}[1]{\ensuremath{\cancelto{1}{\frac{#1}{#1}}}}
```

\chkphysicsquantity undocumented diagnostic command

```
\newcommand{\chkphysicsquantity}[1]{%
  \cs{#1}
}%
```

\vecto new \vect that allows for subscripts

```
\newcommandx{\vecto}[2][2,usedefault]{\ensuremath{%
  \ifthenelse{\equal{#2}{}}%
    {\vec{\mathrm #1}}%
    {\ssub{\vec{\mathrm #1}}{#2}}}}%
```

\compvecto new \compvect that allows for subscripts

```
\newcommandx{\compvecto}[3][2,usedefault]{\ensuremath{%
  \ifthenelse{\equal{#2}{}}%
    {\ssub{\mathrm #1}{\(#3\)}}%
    {\ssub{\mathrm #1}{#2,\(#3\)}}}}%
```

\scompsvecto new \scompsvect that allows for subscripts

```
\newcommandx{\scompsvecto}[2][2,usedefault]{\ensuremath{%
  \ifthenelse{\equal{#2}{}}%
    {\lv\compvecto{#1}{x},\compvecto{#1}{y},\compvecto{#1}{z}\rv}%
    {\lv\compvecto{#1}[#2]{x},\compvecto{#1}[#2]{y},\compvecto{#1}[#2]{z}\rv}}}%
```

\compposo new \comppos that allows for subscripts

```
\newcommandx{\compposo}[2][1,usedefault]{\ensuremath{%
  \ifthenelse{\equal{#1}{}}%
    {#2}%
    {\ssub{#2}{#1}}}}%
```

\scompsposo new \scompspos that allows for subscripts

```
\newcommandx{\scompsposo}[1][1,usedefault]{\ensuremath{%
  \ifthenelse{\equal{#1}{}}%
    {\lv\compposo{x},\compposo{y},\compposo{z}\rv}%
    {\lv\compposo[#1]{x},\compposo[#1]{y},\compposo[#1]{z}\rv}}}%
```

7 Acknowledgements

I thank Marcel Heldoorn, Joseph Wright, Scott Pakin, Aaron Titus, Ruth Chabay, and Bruce Sherwood. Special thanks to Martin Scharrer for his `sty2dtx.pl` utility, which saved me days of typing. Special thanks also to Herbert Schulz for his custom `dtx` engine for `TeXShop`. Very special thanks to Ulrich Diez for providing the mechanism that defines scalar and vector quantities.

8 Index

Numbers written in italic refer to the page/codeline where the corresponding entry is described; numbers/codelines underlined refer to the definition; numbers in roman refer to the pages/codelines where the entry is used.

E

F

G

H

I

K

L

M

N

O

P

Q

R

S

T

U

V

W

X

Y

Z