The mandi package

 $Paul\ J.\ Heafner\ ({\tt heafnerj@gmail.com})$

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Change History

v2.0.0	No longer needs SIunits. It's deprecated 2
General: First public release 2	v2.2.0
v2.1.0	General: Completely reformatted documentation. 2
General: Added more predefined quantities 2	Many new physical quantities and constants 2
Coexists with physymb. Load physymb before	New commands, some deprecated in favor of
mandi 2	$\verb mivector $
Coexists with siunitx 2	Physical constants are given to three or four
Improved vector operators 2	decimal places 2
Possible Future Enhancements	
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1 Introduction

This package provides a collection of commands useful in introductory physics and astronomy. The underlying philosophy is that the user, potentially an introductory student, should just type the name of a physical quantity, with a numerical value if needed, without having to think about the units. mandi will typeset everything correctly. For symbolic quantities, the user should type only what is necessary to get the desired result. What one types should correspond as closely as possible to what one thinks when writing. The package name derives from Matter & Interactions¹ by Ruth Chabay and Bruce Sherwood. The package certainly is rather tightly tied to that textbook but can be used for typesetting any document that requires consistent physics notation. With mandi many complicated expressions can be typeset with just a single command. Great thought has been given to command names and I hope users find the conventions logical and easy to remember.

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

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

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

2 Building From Source

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

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

3 Loading the Package

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

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

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

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

4 Usage

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

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

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

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

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

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

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

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

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

```
\energyprinciple E_{\rm sys,f} = E_{\rm sys,i} + W_{\rm ext} + Q
```

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

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

5 Features and Commands

5.1 Autosized Parentheses

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

```
(\oofpezmathsymbol) is how it looks in text mode. (\frac{1}{4\pi\epsilon_{_{0}}}) \text{ is how it looks in text mode.}
```

```
\( (\oofpezmathsymbol) \) is how it looks in math mode. \left(\frac{1}{4\pi\epsilon_{\rm o}}\right) \text{ is how it looks in math mode.}
```

5.2 SI Base Units

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

 \m

Command for metre, the SI unit of spatial displacement (length).

\kg

Command for kilogram, the SI unit of mass.

\s

Command for second, the SI unit of temporal displacement (duration).

\A

Command for ampere, the SI unit of electric current.

\K

Command for kelvin, the SI unit of thermodynamic temperature.

\mol

Command for mole, the SI unit of amount.

\cd

Command for candela, the SI unit of luminous intensity.

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

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

5.3 Defining Physics Quantities

 $\newphysicsquantity{\langle newname \rangle}{\langle baseunits \rangle}[\langle drvdunits \rangle][\langle tradunits \rangle]$ Defines a new physics quantity and its associated commands.

Using this command causes several things to happen.

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

5.3.1 Defining Vector Quantities

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

5.4 First Semester Physics

The first semester of $Matter \,\mathcal{C}$ Interactions and indeed most traditional introductory calculus-based physics course, focuses on mechanics, dynamics, and statistical mechanics.

5.4.1 Predefined Quantities

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

 $\langle displacement \{ \langle magnitude \rangle \}$ Command for displacement.

<pre>a displacement of \displacement{5} \\ a displacement of \displacement{\mivector{3,2,-1}}</pre>	a displacement of 5 m a displacement of $\langle 3,2,-1\rangle\mathrm{m}$
$\mbox{$\$	
a mass of \mass{5}	a mass of $5 \mathrm{kg}$
$\begin{array}{c} \mathbf{duration} \{ \langle magnitude \rangle \} \\ \mathbf{Command for duration.} \end{array}$	
a duration of \duration{5}	a duration of $5\mathrm{s}$
$\langle \text{current} \{ \langle magnitude \rangle \} $ Command for current.	
a current of \current{5}	a current of $5\mathrm{A}$
$\cline{temperature} {\langle magnitude \rangle} $ Command for temperature.	
a temperature of \temperature{5}	a temperature of $5\mathrm{K}$
$\operatorname{Command} \{\langle magnitude \rangle \}$ Command for amount.	
an amount of \amount{5}	an amount of 5 mol
$\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ $	
a luminous intensity of \luminous{5}	a luminous intensity of 5 cd
W71:11 2	

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

$\protect\operatorname{planeangle}(\langle magnitude \rangle)$

Command for plane angle in radians.

a plane angle of \planeangle{5}	a plane angle of $5\mathrm{rad}$
a plane angle of (planeangle(e)	a plane angle of orac

$\sl (magnitude)$

Command for solidangle.

a solid angle of \solidangle{5}	a solid angle of $5\mathrm{sr}$
---------------------------------	---------------------------------

$\ightharpoonup (magnitude)$

Command for plane angle in degrees.

a plane angle of \indegrees{5}	a plane angle of 5 $^{\circ}$

$\verb|\inarcminutes|| \langle magnitude \rangle||$

Command for plane angle in minutes of arc.

$\incseconds{\langle magnitude \rangle}$

Command for plane angle in seconds of arc.

an angle of \inarcseconds{5}	an angle of $5^{\prime\prime}$	
	The state of the s	

$\infarenheit{\langle magnitude \rangle}$

Command for temperature in degrees Farenheit.

a temperature of \inFarenheit{68}	a temperature of 68 $^{\circ}\mathrm{F}$
-----------------------------------	--

$\in Celsius \{\langle magnitude \rangle\}$

Command for temperature in degrees Celsius.

a temperature of \inCelsius{20}	a temperature of $20^{\circ}\mathrm{C}$
---------------------------------	---

Command for energy in electron volts.

an energy of \n an energy of $10.2\mathrm{eV}$	an energy of \ineV{10.2}	an energy of $10.2\mathrm{eV}$
--	--------------------------	--------------------------------

$\interpretation \label{limited} \label{limited} $$ \interpretation \label{limited} $$

Command for mass in $\mathrm{MeV/}c^2.$

a mass of \inMeVocs{0.511}	a mass of $0.511\mathrm{MeV/}c^2$
----------------------------	-----------------------------------

$\int MeVoc{\langle magnitude \rangle}$

Command for momentum in MeV/c.

a momentum of \inMeVoc{3.6}	a momentum of $3.6\mathrm{MeV}/c$
-----------------------------	-----------------------------------

$\verb|\inAU|{|\langle} magnitude|{|\rangle}|$

Command for displacement in astronomical units.

a semimajor axis of \inAU{5.2}	a semimajor axis of $5.2\mathrm{AU}$

$\verb|\inly{|} \langle magnitude \rangle \}$

Command for displacement in light years.

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

$\incyr{\langle magnitude \rangle}$

Command for displacement in light years written differently.

a distance of \incyr{4.3}	a distance of $4.3c\cdot \text{year}$
---------------------------	---------------------------------------

$\inc{\langle magnitude \rangle}$

Command for displacement in parsecs.

a distance of \inpc{4.3}	a distance of \inpc{4.3}	a distance of $4.3\mathrm{pc}$
--------------------------	--------------------------	--------------------------------

Command for luminosity in solar multiples.

a luminosity of \insolarL{4.3}	a luminosity of $4.3L_{\odot}$
--------------------------------	--------------------------------

Command for temperature in solar multiples.

a temperature of \insolarT{2}	a temperature of $2T_{\odot}$
-------------------------------	-------------------------------

Command for radius in solar multiples.

a radius of \insolarR{4.3}	a radius of $4.3R_{\odot}$
----------------------------	----------------------------

Command for mass in solar multiples.

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

$\verb|\insolarF{|} \langle magnitude \rangle \}|$

Command for flux in solar multiples.

Command for apparent flux in solar multiples.

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

$\mbox{\scalebox{$\backslash$insolarMag}{\langle magnitude \rangle$}}$

Command for absolute magnitude in solar multiples.

an absolute magnitude of \insolarMag{2}	an absolute magnitude of $2M_{\odot}$
---	---------------------------------------

Command for apparent magnitude in solar multiples.

an apparent magnitude of \insolarmag{2}	an apparent magnitude of $2m_{_{\bigodot}}$
---	---

Command for distance in solar multiples.

a distance of \insolarD{2}	a distance of $2D_{\odot}$
----------------------------	----------------------------

Identical to $\$ but uses d.

a distance of \insolard{2}	a distance of $2d_{_{\bigodot}}$
----------------------------	----------------------------------

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

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

$\velocityc{\langle magnitude \rangle}$

Command for magnitude of velocity as a fraction of c.

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


Command for magnitude of velocity.

```
a velocity of \velocity{2.34} \\ a velocity of \velocity{\mivector{3,2,-1}} a velocity of \langle 3,2,-1 \rangle m/s
```

$\label{lorentz} {\mbox{(} magnitude\mbox{)}}$

Command for relativistic Lorentz factor.

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

$\mbox{\constraint} (magnitude)$

Command for momentum.

```
a momentum of \momentum{2.34} \\ a momentum of \momentum{\mivector{3,2,-1}} \ a momentum of \langle 3,2,-1 \rangle \ kg \cdot m/s
```

$\acceleration{\langle magnitude \rangle}$

Command for acceleration.

```
an acceleration of \acceleration{2.34} \\ an acceleration of 2 \\ \acceleration \left\{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\matr\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\mathrm{\
```

$\ightharpoonup \{\langle magnitude \rangle\}$

Command for impulse.

```
an impulse of \impulse{2.34} \\ an impulse of \impulse{\mivector{3,2,-1}} an impulse of \langle 3,2,-1\rangle \log \cdot m/s
```

$\force{\langle magnitude \rangle}$

Command for force.

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

$\verb|\springstiffness{|} \langle magnitude \rangle |$

Command for spring stiffness.

a spring stiffness of \springstiffness{2.34}

a spring stiffness of $2.34\,\mathrm{N/m}$

$\sl magnitude$

Command for spring stretch.

a spring stretch of \springstretch{2.34}

a spring stretch of $2.34\,\mathrm{m}$

$\area{\langle magnitude \rangle}$

Command for area.

an area of \area{2.34}

an area of $2.34\,\mathrm{m}^2$

Command for volume.

a volume of \volume{2.34}

a volume of $2.34\,\mathrm{m}^3$

$\label{linearmassdensity} {\mbox{$\langle magnitude \rangle$}}$

Command for linear mass density.

a linear mass density of \linearmassdensity{2.34}

a linear mass density of $2.34\,\mathrm{kg/m}$

$\areamassdensity{\langle magnitude \rangle}$

Command for area mass density.

an area mass density of \areamassdensity{2.34}

an area mass density of $2.34 \, \mathrm{kg/m^2}$

$\verb|\volumemassdensity| \{ \langle magnitude \rangle \}|$

Command for volume mass density.

a volume mass density of \volume mass density $\{2.34\}$

a volume mass density of $2.34\,\mathrm{kg/m}^3$

Command for Young's modulus.

(\youngsmodulus{\scin[2.34]{9}}	a Young's modulus of $2.34 \times 10^9 \mathrm{Pa}$
$\operatorname{ork}\{\langle magnitude \rangle\}$ Command for work.	
an amount of work \work{2.34}	an amount of work $2.34\mathrm{N}\cdot\mathrm{m}$
$\frac{\text{nergy}}{\langle magnitude \rangle}$ Command for energy. Work and energy have	we the same unit, but are conceptually different.
an amount of energy \energy{2.34}	an amount of energy $2.34\mathrm{N}\cdot\mathrm{m}$
ower $\{\langle magnitude \rangle\}$ Command for power.	
an amount of power \power{2.34}	an amount of power $2.34\mathrm{J/s}$
$\begin{array}{c} \textbf{ngularvelocity}\{\langle magnitude \rangle\} \\ \\ \text{Command for angular velocity.} \end{array}$	
an angular velocity of \angularvelocity{2.34}	an angular velocity of $2.34\mathrm{rad/s}$
an angular velocity of \angularvelocity{2.34} $ \frac{\text{ngularacceleration}\{\langle magnitude \rangle\}}{\text{Command for angular acceleration}}. $	an angular velocity of 2.34 rad/s

an angular momentum of $\aggray \{2.34\}$

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

$\mbox{\colored}(\mbox{\colored}(\mbox{\colored})$

Command for moment of inertia.

a moment of inertia of \momentofinertia{2.34}

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

$\texttt{torque}\{\langle magnitude \rangle\}$

Command for torque.

a torque of \torque{2.34}

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

$\ensuremath{\mbox{entropy}} \{\langle magnitude \rangle\}$

Command for entropy.

an entropy of \entropy{2.34}

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

$\wedge \ \mbox{\wavelength} \{\langle magnitude \rangle\}$

Command for wavelength.

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

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

$\wedge {agnitude}$

Command for wavenumber.

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

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

$\frac{\operatorname{quency}\{\langle magnitude \rangle\}}$

Command for frequency.

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

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

$\agnitude \$

Command for angular frequency.

an angular frequency of ? (\angularfrequency{\scin[4.70]{15}}	an angular frequency of $4.70 \times 10^{15} \mathrm{rad/s}$
---	--

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 $Matter\ \mathcal{E}\ Interactions$ focuses on electromagnetic theory, and there are many primary and secondary quantities.

5.5.1 Predefined Quantities

Command for electric charge.

a charge of \charge{\scin[2]{-9}}	charge of 2×10^{-9} C
-----------------------------------	--------------------------------

 $\operatorname{permittivity}\{\langle magnitude \rangle\}$

Command for permittivity.

<pre>a permittivity of \permittivity{\scin[9]{-12}}</pre>	a permittivity of $9 \times 10^{-12} \mathrm{C^2/N \cdot m^2}$
---	---

 $\ensuremath{\mbox{\ensuremath{\mbox{\sc leave}}}\mbox{\sc leave}}$

Command for electric dipole moment.

an electric dipole moment of ? (\electricdipolemoment{\scin[2]{5}}	an electric dipole moment of $2 \times 10^5 \mathrm{C} \cdot \mathrm{m}$
--	--

 $\protect\operatorname{\mathtt{ightheta}} \protect\operatorname{\mathtt{ightheta}} \pro$

Command for permeability.

```
a permeability of \permeability{\scin[4\pi]{-7}} a permeability of 4\pi 	imes 10^{-7} \mathrm{T\cdot m/A}
```

$\mbox{\mbox{$\$

Command for magnetic field (also called magnetic induction).

a magnetic field of \magneticfield{1.25}
--

$\colongraphic \colongraphic \colongraphic$

Command for product of c and magnetic field. This quantity is convenient for symmetry.

a magnetic field of \cmagneticfield{1.25} a $\rm m$	agnetic field of $1.25\mathrm{N/C}$
---	-------------------------------------

$\verb|\linearchargedensity| \{ \langle magnitude \rangle \}|$

Command for linear charge density.

a linear charge density of 2 (\linearchargedensity{\scin[4.5]{-3}}	a linear charge density of $4.5 \times 10^{-3} \mathrm{C/m}$
--	--

$\areachargedensity{\langle magnitude \rangle}$

Command for area charge density.

a charge density of $1.25\mathrm{C/m^2}$
98

$\volume charge density \{\langle magnitude \rangle\}$

Command for volume charge density.

a volume charge density of ? (\volumechargedensity{1.25}	a volume charge density of $1.25\mathrm{C/m^3}$
--	---

$\mbox{\em mobility} \{\langle magnitude \rangle\}$

Command for electron mobility.

a mobility of $\areachargedensity{\scin[4.5]{-3}}$	a mobility of $4.5 \times 10^{-3} \mathrm{C/m^2}$
--	---

$\mbox{numberdensity}\{\langle magnitude \rangle\}$

Command for electron number density.

a number density of	\numberdensity{\scin[2]{18}}	a numbe

a number density of $2 \times 10^{18} / \text{m}^3$

$\verb|\polarizability|{|\langle magnitude\rangle|}|$

Command for polarizability.

$\ensuremath{\mbox{\mbox{electric}potential}} \{\langle magnitude \rangle \}$

Command for electric potential.

an electric potential of \polarizability{1.5}	an electric potential of $1.5\mathrm{C\cdot m/(N/C)}$
an disserie possible of (polarizability (176)	an electric percention of 110 c m _j (11, c)

$\ensuremath{\mbox{\sf emf}} \{\langle magnitude \rangle \}$

Command for emf.

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

$\verb|\dielectricconstant{|} \langle magnitude \rangle \}|$

Command for dielectric constant.

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

$\verb|\indexofrefraction{|} \langle magnitude \rangle \}|$

Command for index of refraction.

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

$\ensuremath{\mbox{\mbox{relative}permittivity}} \langle magnitude \rangle \}$

Command for relative permittivity.

a relative permittivity of) (\relativepermittivity{0.9}	a relative permittivity of 0.9
--	--------------------------------

$\ensuremath{\mbox{relative}permeability}\{\langle magnitude \rangle\}$

Command for relative permeability.

a relative permeability of \relativepermeability{0.9}

a relative permeability of 0.9

$\ensuremath{\mbox{energydensity}} \ensuremath{\mbox{(}magnitude\ensuremath{\mbox{)}}}$

Command for energy density.

an energy density of \energydensity{1.25}

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

$\ensuremath{\mbox{\ensuremath}\mbox{\ensuremat$

Command for electron current.

an electron current of \(\(\) \(\

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

$\conventional current \{\langle magnitude \rangle\}$

Command for conventional current.

a conventional current of 2 (\conventionalcurrent{0.003}

a conventional current of 0.003 A

$\mbox{\constraint} (magnitude)$

Command for magnetic dipole moment.

a magnetic dipole moment of 2 \$\footnote{\text{magneticdipolemoment{1.25}}}\$

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

$\colon current density {\langle magnitude \rangle}$

Command for current density.

a current density of \currentdensity{1.25}

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

$\left(\max\{\left\langle magnitude\right\rangle \}\right)$

Command for electric flux.

an electric flux of \electricflux{1.25}

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

 $\mbox{\mbox{\mbox{$\setminus$}}}$

Command for magnetic flux.

a magnetic flux of \magneticflux{1.25}

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

 $\colonermath{\texttt{capacitance}} \langle magnitude \rangle \}$

Command for capacitance.

a capacitance of \capacitance{1.00}

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

Command for inductance.

an inductance of \inductance{1.00}

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

 $\conductivity{\langle magnitude \rangle}$

Command for conductivity.

a conductivity of \conductivity{1.25}

a conductivity of $1.25 \left(A/m^2\right)/\left(V/m\right)$

 $\r (magnitude)$

Command for resistivity.

a resistivity of \resistivity{1.25}

a resistivity of $1.25 \left(V/m \right) / \left(A/m^2 \right)$

Command for resistance.

a resistance of \resistance{\scin[1]{6}}

a resistance of $1\times{10}^{6}\Omega$

 $\conductance{\langle magnitude \rangle}$

Command for conductance.

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

$\mbox{\mbox{$\mbox{magneticcharge}}} \langle \mbox{$\mbox{$magneticcharge}$} \langle \mbox{$\mbox{$magneticcharge}$} \rangle \}$

Command for magnetic charge, in case it actually exists.

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

$\ensuremath{\mbox{energyflux}} \langle magnitude \rangle \}$

Command for energy flux.

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

5.6 Further Words on Units

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

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

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

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

$\hereusebaseunit{\langle magnitude \rangle}$

Command for using base units in place.

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

$\hereusedrvdunit{\langle magnitude \rangle}$

Command for using derived units in place.

<pre>a momentum of \hereusedrvdunit{\momentum{3}}</pre>	a momentum of $3\mathrm{N}\cdot\mathrm{s}$
---	--

$\hereusetradunit{\langle magnitude \rangle}$

Command for using traditional units in place.

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

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

\begin{usebaseunit} \ \ environment content \ \ \end{usebaseunit}

Environment for using base units.

$\label{eq:content} $$ \langle environment\ content \rangle $$$

\end{usedrvdunit}

Environment for using derived units.

\begin{usetradunit} \ \ \ environment content \ \ \ \ \ \ end{usetradunit}

Environment for using traditional units.

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

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

\perpusebaseunit

Command for perpetually using base units.

$\protect\operatorname{\mathtt{ightheta}}$

Command for perpetually using derived units..

$\operatorname{perpusetradunit}\{\langle magnitude \rangle\}$

Command for perpetually using traditional units..

5.7 Symbolic Expressions with Vectors

5.7.1 Basic Vectors

Symbol for a vector quantity.

\vect{p}	$ec{p}$
----------	---------

$\mbox{\mbox{\tt magvect}} \langle kernel \rangle \}$

Symbol for magnitude of a vector quantity.

\magvect{p}	$ ec{p} $
-------------	-----------

$\dirvect{\langle kernel \rangle}$

Symbol for direction of a vector quantity.

\dirvect{p}	\widehat{p}
-------------	---------------

$\mbox{\commadelimited} \$ $\commadelimited list of comps$ $\commadelimited list of comps$

Generic workhorse command for vectors formatted as in $Matter \ \mathcal{C}$ Interactions.

\ncompszerovect

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

\ncompszerovect	$\langle 0,0,0 angle$	

$\space{symvect}{\langle listofcomps \rangle}$

Command for a vector with symbolic components. Deprecated. Use \mivector instead.

<pre>\symvect{\magvect{E}\cos\theta, \magvect{E}\sin\theta,0}</pre>	$\left\langle \left ec{E} ight \cos heta, \left ec{E} ight \sin heta, 0 ight angle$
---	--

$\ncompsvect{\langle listofcomps \rangle} [\langle unit \rangle]$

Command for a vector with numerical components and an optional unit. Deprecated. Use \mivector instead.

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

$\mbox{\mbox{$\backslash$ magvectncomps}{\mbox{\mbox{\langle list of comps$$\rangle$}}[\langle unit\rangle]$}$

Expression for a vector's magnitude with numerical components and an optional unit.

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

$\scalebox{$\scalebox{\sim}}$

Expression for a vector's symbolic components.

\scompsvect{E}	$\left\langle E_{x},E_{y},E_{z}\right\rangle$
----------------	---

$\compvect{\langle kernel \rangle}{\langle component \rangle}$

Isolates one of a vector's symbolic components.

\compvect{E}{y}	$E_y^{}$	
-----------------	----------	--

$\mbox{\mbox{\tt magvectscomps}}\{\langle kernel \rangle\}$

Expression for a vector's magnitude in terms of its symbolic components.

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

5.7.2 Position Vectors

\scompspos

Expression for a position vector's traditional symbolic components.

\scompspos $\langle x,y,z angle$

$\compos{\langle component \rangle}$

Isolates one symbolic component of a position vector.

\comppos{z}	z	

5.7.3 Differentials and Derivatives of Vectors

$\dvect{\langle kernel \rangle}$

Symbol for the differential of a vector.

a change \dvectits in electric field a change dE in electric field	a change \dvect{E} in electric field	a change d $ec{E}$ in electric field
--	--------------------------------------	--------------------------------------

$\verb|\Dvect{|}\langle kernel|\rangle \}$

Identical to \dvect but uses Δ .

a change $\D{\text{vect}}\{E\}$ in electric field	a change $\Delta \vec{E}$ in electric field
---	---

$\dirdvect{\langle kernel \rangle}$

Symbol for the direction of a vector's differential.

the direction \dirdvect{E} of the change	the direction $\widehat{\operatorname{d}\! \vec E}$ of the change
--	---

$\dir Dvect{\langle kernel \rangle}$

Identical to \dirdvect but uses Δ .

the direction \dirDvect{E} of the change	the direction $\widehat{\Delta ec{E}}$ of the change
--	--

$\del{dirvect} \del{dirvect} \del{dirvect}$

Symbol for the differential of a vector's direction.

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

$\Ddirvect{\langle kernel \rangle}$

Identical to \ddirvect but uses Δ .

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

$\mbox{\mbox{\mbox{$\setminus$}}}$

Symbol for the magnitude of a vector's differential.

the magnitude \magdvect{E} of the change $\left| \mathrm{d} ec{E}
ight|$ of the change

$\mbox{\mbox{\tt magDvect}} \langle kernel \rangle \}$

Identical to $\mbox{magdvect}$ but uses Δ .

the magnitude \magDvect{E} of the change $\left|\Delta ec{E}
ight|$ of the change

$\dmagvect{\langle kernel \rangle}$

Symbol for the differential of a vector's magnitude.

the change \dmagvect{E} in the magnitude $|ec{E}|$ in the magnitude

$\Dmagvect{\langle kernel \rangle}$

Identical to \dmagvect but uses Δ .

the change \Dmagvect{E} in the magnitude $|ec{E}|$ in the magnitude

$\scompsdvect{\langle kernel \rangle}$

Symbolic components of a vector.

the	vector	\scompsdvect{E}

the vector $\left\langle \mathrm{d}E_{x}\,,\mathrm{d}E_{y}\,,\mathrm{d}E_{z}\,\right\rangle$

$\scompsDvect{\langle kernel \rangle}$

Identical to \scompsdvect but uses Δ .

the	vector	\scompsDvect{E}

the vector $\left\langle \Delta E_{x}\,,\Delta E_{y}\,,\Delta E_{z}\,\right\rangle$

$\verb|\compdvect{} \langle kernel \rangle \} \{ \langle component \rangle \}$

Isolates one symbolic component of a vector's differential.

the	\compdvect{E}{y}	component	of	the	change
CIIC	(Compared Lin (y)	Component	$O_{\mathbf{T}}$	UIIC	Ciraing

the $\mathrm{d}E_y$ component of the change

$\compDvect{\langle kernel \rangle}{\langle component \rangle}$

Identical to \compdvect but uses Δ .

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

the ΔE_y component of the change

\scompsdpos

Symbolic components of a position vector.

the	change	in	position	\scompsdpos

the change in position $\langle dx, dy, dz \rangle$

\scompsDpos

Identical to \scompsdpos but uses Δ .

the	change	in	nosition	\scompsDpos
cne	Change	TII	position	(acombanhoa

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

$\compdpos\{\langle component \rangle\}$

Isolates one component of a position vector's differential.

the	component	\compdpos{z}	οf	the	change

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

$\compDpos\{\langle component \rangle\}$

Identical to \compdpos but uses Δ .

the component \compDpos{z} of the change

the component Δz of the change

$\dervect{\langle kernel \rangle}{\langle indvar \rangle}$

Symbol for a vector's derivative with respect to an independent variable.

the derivative \dervect{E}{t}

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

$\verb|\Dervect|{\langle kernel\rangle}|{\langle indvar\rangle}|$

Identical to \dervect but uses Δ .

the derivative \Dervect{E}{t}

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

$\dermagvect{\langle kernel \rangle}{\langle indvar \rangle}$

Symbol for the derivative of a vector's magnitude with respect to an independent variable.

the derivative \dermagvect{E}{t}

the derivative $\frac{\mathrm{d}\left|\vec{E}\right|}{\mathrm{d}t}$

$\Dermagvect{\langle kernel \rangle}{\langle indvar \rangle}$

Identical to \dermagvect but uses Δ .

the derivative \Dermagvect{E}{t}

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

$\scompsdervect{\langle kernel \rangle}{\langle indvar \rangle}$

Symbolic components of a vector's derivative with respect to an independent variable.

the derivative \scompsdervect{E}{t}

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

$\scompsDervect{\langle kernel \rangle}{\langle indvar \rangle}$

Identical to \scompsdervect but uses Δ .

the derivative \scompsdervect{E}{t}

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

$\compdervect{\langle kernel \rangle}{\langle component \rangle}{\langle indvar \rangle}$

Isolates one component of a vector's derivative with respect to an independent variable.

the derivative \compdervect{E}{y}{t}

the derivative
$$\frac{\mathrm{d}E_{y}}{\mathrm{d}t}$$

$\verb|\compDervect|{\langle kernel \rangle}|{\langle component \rangle}|{\langle indvar \rangle}|$

Identical to \compdervect but uses Δ .

the derivative \compDervect{E}{y}{t}

the derivative
$$\frac{\Delta E_y}{\Delta t}$$

$\mbox{\mbox{$\mbox{magdervect}$}} \langle kernel \rangle \} \{ \langle indvar \rangle \}$

Symbol for the magnitude of a vector's derivative with respect to an independent variable.

the derivative \magdervect{E}{t}

the derivative
$$\left| \frac{\mathrm{d}\vec{E}}{\mathrm{d}t} \right|$$

Identical to \magdervect but uses Δ .

the derivative \magDervect{E}{t}

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

$\scompsderpos\{\langle indvar \rangle\}$

Symbolic components of a position vector's derivative with respect to an independent variable.

the derivative \scompsderpos{t}

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

$\scompsDerpos\{\langle indvar \rangle\}$

Identical to \scompsderpos but uses Δ .

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

$\compderpos\{\langle component \rangle\}\{\langle indvar \rangle\}$

Isolates one component of a vector's derivative with respect to an independent variable.

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

 $\compDerpos\{\langle component \rangle\}\{\langle indvar \rangle\}$

Identical to \compderpos but uses Δ .

the derivative $\compDerpos\{z\}\{t\}$
--

5.7.4 Naming Conventions You Have Seen

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

5.7.5 Subscripted or Indexed Vectors

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

Symbol for a subscripted vector.

the vector \vectsub{p}{ball}	the vector $\vec{p}_{ ext{ball}}$
------------------------------	-----------------------------------

 $\mbox{\mbox{$\mbox{magvectsub}}} \langle kernel \rangle \} \{ \langle sub \rangle \}$

Symbol for a subscripted vector's direction.

		the	direction	\dirvectsub{p}{ball}
--	--	-----	-----------	----------------------

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

$\directsub{\langle kernel \rangle}{\langle sub \rangle}$

Symbol for a subscripted vector's magnitude.

the	magnitude	\magvectsub{p}{ball}

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

$\scompsvectsub\{\langle kernel \rangle\}\{\langle sub \rangle\}\$

Symbolic components of a subscripted vector.

the	vector	\scompsvectsub{p}{ball}

the vector $\left\langle \boldsymbol{p}_{x,\text{ball}}, \boldsymbol{p}_{y,\text{ball}}, \boldsymbol{p}_{z,\text{ball}} \right\rangle$

$\verb|\compvectsub|{\langle kernel \rangle}|{\langle component \rangle}|{\langle sub \rangle}|$

Isolates one component of a subscripted vector.

the component $p_{z,\text{ball}}$

$\verb|\magvectsubscomps|{|\langle kernel\rangle|}{|\langle sub\rangle|}$

Expression for a subscripted vector's magnitude in terms of symbolic components.

the	magnitude	\magvectsubscomps{p}{ball}

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

$\scompspossub{\langle sub \rangle}$

Symbolic components of a subscripted position vector.

the	vector	\scompspossub{ball}

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

$\verb|\compossub|{|\langle component \rangle|} {|\langle sub \rangle|}$

Isolates one component of a subscripted position vector.

the component \comppossub{x}{ball}

the component x_{ball}

$\dvectsub{\langle kernel \rangle}{\langle sub \rangle}$

Differential of a subscripted vector.

the change \dvectsub{p}{ball}

the change ${\rm d}\vec{p}_{_{\rm ball}}$

$\Dvectsub{\langle kernel \rangle}{\langle sub \rangle}$

Identical to \dvectsub but uses Δ .

the change \Dvectsub{p}{ball}

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

$\scompsdvectsub\{\langle kernel \rangle\}\{\langle sub \rangle\}$

Symbolic components of a subscripted vector's differential.

the vector \scompsdvectsub{p}{ball}

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

$\scompsDvectsub\{\langle kernel \rangle\}\{\langle sub \rangle\}$

Identical to \scompsdvectsub but uses Δ .

the vector \scompsDvectsub{p}{ball}

the vector $\left<\Delta p_{_{x,\text{ball}}}, \Delta p_{_{y,\text{ball}}}, \Delta p_{_{z,\text{ball}}}\right>$

$\verb|\compdvectsub|{\langle kernel\rangle}|{\langle component\rangle}|{\langle sub\rangle}|$

Isolates one component of a subscripted vector's differential.

the component \compdvectsub{p}{y}{ball}

the component $dp_{y,\text{ball}}$

$\compDvectsub{\langle kernel \rangle}{\langle component \rangle}{\langle sub \rangle}$

Identical to \compdvectsub but uses Δ .

the component \compDvectsub{p}{y}{ball}

the component $\Delta p_{y,\text{ball}}$

$\scompsdpossub{\langle sub \rangle}$

Symbolic components of a subscripted position vector's differential.

the	vector	\scompsdpossub{ball}

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

$\scompsDpossub{\langle sub \rangle}$

Identical to \scopmsdpossub but uses Δ .

the vector	\scompsDpossub{ball}

the vector
$$\left<\Delta x_{_{\rm ball}}, \Delta y_{_{\rm ball}}, \Delta z_{_{\rm ball}}\right>$$

$\compdpossub{\langle component \rangle}{\langle sub \rangle}$

Isolates one component of a subscripted position vector's differential.

the component \compdpossub{x}{b

the component $\mathrm{d}x_{\mathrm{ball}}$

$\compDpossub{\langle component \rangle}{\langle sub \rangle}$

Identical to \compdpossub but uses Δ .

the	component	\compDpossub{x}{ball}

the component Δx_{ball}

$\dervectsub\{\langle kernel \rangle\}\{\langle sub \rangle\}\{\langle indvar \rangle\}$

Symbol for derivative of a subscripted vector with respect to an independent variable.

the derivative	\dervectsub{p}{ball}{t}

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

$\label{eq:local_local_local} $$\operatorname{Condense}(\langle sub \rangle) {\langle sub \rangle} {\langle indvar \rangle} $$$

Identical to \dervectsub but uses Δ .

the derivative $\frac{\Delta \vec{p}_{\text{ball}}}{\Delta t}$

$\label{eq:dermagvectsub} $$ \operatorname{dermagvectsub} {\langle kernel \rangle} {\langle sub \rangle} {\langle indvar \rangle} $$$

Symbol for the derivative of a subscripted vector's magnitude with respect to an independent variable.

the derivative \dermagvectsub{E}{ball}{t}

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

$\verb|\Dermagvectsub|{\langle kernel\rangle}|{\langle sub\rangle}|{\langle indvar\rangle}|$

Identical to \dermagvectsub but uses Δ .

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

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

$\scompsdervectsub\{\langle kernel \rangle\}\{\langle sub \rangle\}\{\langle indvar \rangle\}$

Symbolic components of a subscripted vector's derivative with respect to an independent variable.

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

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

$\verb|\scompsDervectsub|{\langle kernel \rangle} {\langle sub \rangle} {\langle indvar \rangle}$

Identical to \scompsdervectsub but uses Δ .

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

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

$\verb|\compdervectsub|{\langle kernel\rangle}|{\langle component\rangle}|{\langle sub\rangle}|{\langle indvar\rangle}|$

Isolates one component of a subscripted vector's derivative with respect to an independent variable.

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

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

$\verb|\compDervectsub|{\langle kernel \rangle}|{\langle component \rangle}|{\langle sub \rangle}|{\langle indvar \rangle}|$

Identical to \compdervectsub but uses Δ .

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

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

$\mbox{\mbox{$\$

Symbol for magnitude of a subscripted vector's derivative with respect to an independent variable.

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

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

$\mbox{\mbox{$\$

Identical to \magdervectsub but uses Δ .

$\scompsderpossub{\langle sub \rangle} {\langle indvar \rangle}$

Symbolic components of a subscripted position vector's derivative with respect to an independent variable.

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

$\scompsDerpossub{\langle sub \rangle} {\langle indvar \rangle}$

Identical to \scompsderpossub but uses Δ .

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

$\verb|\compderpossub|{\langle component\rangle}|{\langle sub\rangle}|{\langle indvar\rangle}|$

Isolates one component of a subscripted position vector's derivative with respect to an independent variable.

 $\verb|\compDerpossub|{|\langle component|\rangle}|{|\langle sub|\rangle}|{|\langle indvar|\rangle}|$

Identical to \compderpossub but uses Δ .

5.7.6 Relative Vectors

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

$\rcline{\langle sub \rangle}$

Symbol for relative position.

the vector \relpos{12} the vector \vec{r}_{12}	the vector \relpos{12}	the vector \vec{r}_{12}
--	------------------------	---------------------------

Symbol for relative velocity.

the vector \relvel{12}	the vector \vec{v}_{12}
------------------------	---------------------------

\mathbf{sub}

Symbol for relative momentum.

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

\rcline{sub}

Symbol for relative force.

5.7.7 Expressions Containing Dots

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

Symbol for dot of two vectors as a single symbol.

\vectdotvect{\vect{F}}{\vect{v}}	$ec{F} ullet ec{v}$	
----------------------------------	---------------------	--

Symbol for dot of two vectors with symbolic components.

\vectdotsvect{F}{v}	$\left\langle F_{x},F_{y},F_{z}\right\rangle \bullet\left\langle v_{x},v_{y},v_{z}\right\rangle$

$\colone{location} \colone{location} \colone{lo$

Symbol for dot of two vectors as an expanded sum.

\vectdotevect{F}{v}

$$F_x \, v_x \, + F_y \, v_y \, + F_z \, v_z$$

Dot of a vector and a position vector with symbolic components.

\vectdotspos{F}

$$\left\langle F_{x}\,,F_{y}\,,F_{z}\,\right\rangle \bullet \left\langle x,y,z\right\rangle$$

Dot of a vector and a position vector as an expanded sum.

\vectdotepos{F}

$$F_x\,x+F_y\,y+F_z\,z$$

Dot of a vector's differential with symbolic components.

\vectdotsdvect{F}{r}

$$\left\langle F_{x}^{{}},F_{y}^{{}},F_{z}^{{}}\right\rangle \bullet \left\langle \mathrm{d}r_{x}^{{}},\mathrm{d}r_{y}^{{}},\mathrm{d}r_{z}^{{}}\right\rangle$$

$\colone{location} \colone{location} \colone{lo$

Identical to $\ensuremath{\mbox{\sc vectdotsdvect}}$ but uses Δ .

\vectdotsDvect{F}{r}

$$\left\langle F_{x}^{{}},F_{y}^{{}},F_{z}^{{}}\right\rangle ullet \left\langle \Delta r_{x}^{{}},\Delta r_{y}^{{}},\Delta r_{z}^{{}}\right
angle$$

Dot of a vector a vector's differential as an expanded sum.

\vectdotedvect{F}{r}

$$F_x \, {\rm d} r_x \, + F_y \, {\rm d} r_y \, + F_z \, {\rm d} r_z$$

$\ensuremath{\mbox{vectdoteDvect}(\langle kernel1\rangle)}{\langle kernel2\rangle}$

Identical to \vectdotedvect but uses Δ .

\vectdotel	A	רייו	r1
\vectaote	vect.	ነድዮ	1 I i

$$F_x\,\Delta r_x\,+F_y\,\Delta r_y\,+F_z\,\Delta r_z$$

Dot of a vector and a position vector's differential with symbolic components.

\vectdotsdpos{F}

$$\left\langle F_{x}\,,F_{y}\,,F_{z}\,\right\rangle \bullet \left\langle \mathrm{d}x,\mathrm{d}y,\mathrm{d}z\right\rangle$$

Identical to \vee vectdotsdpos but uses Δ .

\vectdotsDpos{F}

$$\left\langle \boldsymbol{F}_{x}\,,\boldsymbol{F}_{y}\,,\boldsymbol{F}_{z}\,\right\rangle \bullet \left\langle \Delta x,\Delta y,\Delta z\right\rangle$$

Dot of a vector and a position vector's differential as an expanded sum.

\vectdotedpos{F}

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

$\colon \colon \colon$

Identical to \vectdotedpos but uses Δ .

\vectdoteDpos{F}

$$F_x \, \Delta x + F_y \, \Delta y + F_z \, \Delta z$$

$\label{eq:ctsubdotsvectsub} $$\operatorname{\langle kernel1\rangle}_{\langle sub1\rangle}_{\langle sub1\rangle}_{\langle sub2\rangle}_{\langle sub2\rangle}_$

Dot of two subscripted vectors with symbolic components.

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

$$\left\langle F_{x, \text{grav}}, F_{y, \text{grav}}, F_{z, \text{grav}} \right\rangle \bullet \left\langle r_{x, \text{ball}}, r_{y, \text{ball}}, r_{z, \text{ball}} \right\rangle$$

$\label{eq:ctsubdotevectsub} $$\operatorname{ctsubdotevectsub}(\langle kernel1\rangle) = (\langle sub1\rangle) = (\langle sub2\rangle) =$

Dot of two subscripted vectors as an expanded sum.

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

$$F_{x, \text{grav}} r_{x, \text{ball}} + F_{y, \text{grav}} r_{y, \text{ball}} + F_{z, \text{grav}} r_{z, \text{ball}}$$

Dot of a subscripted vector and a subscripted vector's differential with symbolic components.

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

$\label{eq:local_vectsub} $$\operatorname{\colored}(\langle sub1\rangle) = (\langle sub1\rangle) = (\langle sub2\rangle) = (\langle$

Identical to \vectsubdotsdvectsub but uses Δ .

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

$\label{eq:ctsubdotedvectsub} $$\operatorname{ctsubdotedvectsub}(\langle kernel1\rangle) = (\langle sub1\rangle) = (\langle sub2\rangle) = (\langle sub2\rangle)$

Dot of a subscripted vector and a subscripted vector's differential as an expanded sum.

 $\label{eq:car} $$\operatorname{A}_{x,\operatorname{ball}} \mathrm{d}B_{x,\operatorname{car}} + A_{y,\operatorname{ball}} \mathrm{d}B_{y,\operatorname{car}} + A_{z,\operatorname{ball}} \mathrm{d}B_{z,\operatorname{car}} + A_{z,\operatorname{ball}} \mathrm{d}B_{z,\operatorname{ball}} + A_{z,\operatorname{ball}} \mathrm{d}B_{z,\operatorname{ball}} + A_{z,\operatorname{ball}} + A_$

$\label{eq:local_vectsub} $$\operatorname{ctsubdoteDvectsub}(\langle kernel1\rangle)_{\langle sub1\rangle}_{\langle sub1\rangle}_{\langle sub2\rangle}_{\langle s$

Identical to \vectsubdotedvectsub but uses Δ .

 $\label{eq:alphabeta} $$\operatorname{Dvectsub}(A)_{a}=A_{x,\operatorname{ball}} \Delta B_{x,\operatorname{car}} + A_{y,\operatorname{ball}} \Delta B_{y,\operatorname{car}} + A_{z,\operatorname{ball}} \Delta B_{z,\operatorname{car}} + A_{z,\operatorname{ball}} \Delta B_$

Dot of a subscripted vector and a vector's differential with symbolic components.

 $\left\langle A_{x,\text{ball}}, A_{y,\text{ball}}, A_{z,\text{ball}} \right\rangle \bullet \left\langle \text{d}B_x, \text{d}B_y, \text{d}B_z \right\rangle$

Identical to \vectsubdotsdvect but uses Δ .

 $\left\langle A_{x,\text{ball}}, A_{y,\text{ball}}, A_{z,\text{ball}} \right\rangle \bullet \left\langle \Delta B_x, \Delta B_y, \Delta B_z \right\rangle$

Dot of a subscripted vector and a vector's differential as an expanded sum.

\vectsubdotedvect{A}{ball}{B}

$$A_{_{x,\mathrm{ball}}} \, \mathrm{d}x_{_B} \, + A_{_{y,\mathrm{ball}}} \, \mathrm{d}y_{_B} \, + A_{_{z,\mathrm{ball}}} \, \mathrm{d}z_{_B}$$

 $\vectsubdoteDvect{\langle kernel1 \rangle}{\langle sub1 \rangle}{\langle kernel2 \rangle}$

Identical to \vectsubdotedvect but uses Δ .

\vectsubdoteDvect{A}{ball}{B}

$$A_{x,\mathrm{ball}} \Delta x_B^{} + A_{y,\mathrm{ball}}^{} \Delta y_B^{} + A_{z,\mathrm{ball}}^{} \Delta z_B^{}$$

Dot of a subscripted vector and a position vector's differential with symbolic components.

\vectsubdotsdpos{A}{ball}

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

Identical to \vectsubdotsdpos but uses Δ .

\vectsubdotsDpos{A}{ball}

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

Dot of a subscripted vector and a position vector's differential as an expanded sum.

\vectsubdotedpos{A}{ball}

$$A_{x,\text{ball}} dx + A_{y,\text{ball}} dy + A_{z,\text{ball}} dz$$

 $\colonerright \colonerright \colonerright$

Identical to \vectsubdotedpos but uses Δ .

\vectsubdoteDpos{A}{ball}

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

 $\derivectdotsvect{\langle kernel1 \rangle}{\langle indvar \rangle}{\langle kernel2 \rangle}$

Dot of a vector's derivative and a vector with symbolic components.

\dervectdotsvect{A}{t}{B}

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

$\label{eq:decomposition} $$\operatorname{Dervectdotsvect}(\langle kernel1\rangle) = (\langle indvar\rangle) = (\langle kernel2\rangle) $$$

Identical to \dervectdotsvect but uses Δ .

\Dervectdotsvect{A}{t}{B}

$$\left\langle \frac{\Delta A_{_{x}}}{\Delta t},\frac{\Delta A_{_{y}}}{\Delta t},\frac{\Delta A_{_{z}}}{\Delta t}\right\rangle \bullet \left\langle B_{_{x}},B_{_{y}},B_{_{z}}\right\rangle$$

$\label{lem:derivative} $$\dervectdotevect{$\langle kernel1\rangle$} {\langle indvar\rangle$} {\langle kernel2\rangle$}$

Dot of a vector's derivative and a vector as an expanded sum.

\dervectdotevect{A}{t}{B}

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

Identical to \dervectdotevect but uses Δ .

\Dervectdotevect{A}{t}{B}

$$\frac{\Delta A_x}{\Delta t} x_{\scriptscriptstyle B} + \frac{\Delta A_y}{\Delta t} y_{\scriptscriptstyle B} + \frac{\Delta A_z}{\Delta t} z_{\scriptscriptstyle B}$$

$\ensuremath{\mbox{vectdotsdervect}} \langle kernel1 \rangle \} \{ \langle kernel2 \rangle \} \{ \langle indvar \rangle \}$

Dot of a vector and a vector's derivative with symbolic components.

\vectdotsdervect{A}{B}{t}

$$\left\langle \boldsymbol{A}_{x}\,,\boldsymbol{A}_{y}\,,\boldsymbol{A}_{z}\,\right\rangle \bullet \left\langle \frac{\mathrm{d}\boldsymbol{B}_{x}}{\mathrm{d}t},\frac{\mathrm{d}\boldsymbol{B}_{y}}{\mathrm{d}t},\frac{\mathrm{d}\boldsymbol{B}_{z}}{\mathrm{d}t}\right\rangle$$

$\colone{line} \colone{line} \colone{line}$

Identical to \vectdotsdervect but uses Δ .

\vectdotsDervect{A}{B}{t}

$$\left\langle \boldsymbol{A}_{x}\,,\boldsymbol{A}_{y}\,,\boldsymbol{A}_{z}\,\right\rangle \bullet \left\langle \frac{\Delta \boldsymbol{B}_{x}}{\Delta t}\,,\frac{\Delta \boldsymbol{B}_{y}}{\Delta t}\,,\frac{\Delta \boldsymbol{B}_{z}}{\Delta t}\right\rangle$$

$\ensuremath{\mbox{vectdotedervect}(\langle kernel1\rangle)}{\langle kernel2\rangle}{\langle indvar\rangle}$

Dot of a vector and a vector's derivative as an expanded sum.

\vectdotedervect{A}{B}{t}

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

$\ensuremath{\mbox{vectdoteDervect}\{\langle kernel1\rangle\}\{\langle kernel2\rangle\}\{\langle indvar\rangle\}}$

Identical to \vectdotedervect but uses Δ .

$$A_{x} \, \frac{\Delta B_{x}}{\Delta t} + A_{y} \, \frac{\Delta B_{y}}{\Delta t} + A_{z} \, \frac{\Delta B_{z}}{\Delta t}$$

$\derivectdotspos\{\langle kernel \rangle\}\{\langle indvar \rangle\}$

Dot of a vector's derivative and a position vector with symbolic components.

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

$\Dervectdotspos\{\langle kernel \rangle\}\{\langle indvar \rangle\}$

Identical to \dervectdotspos but uses Δ .

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

$\verb|\dervectdotepos|{|\langle kernel\rangle|} | |\langle indvar\rangle| |$

Dot of a vector's derivative and a position vector as an expanded sum.

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

$\verb|\Dervectdotepos|{|\langle kernel\rangle|} {|\langle indvar\rangle|}$

Identical to \dervectdotepos but uses Δ .

$$\frac{\Delta A_{x}}{\Delta t}x+\frac{\Delta A_{y}}{\Delta t}y+\frac{\Delta A_{z}}{\Delta t}z$$

$\label{eq:derivative} $$ \operatorname{dervectdotsdvect}(\langle kernel1\rangle) = (\langle indvar\rangle) = (\langle kernel2\rangle) $$$

Dot of a vector's derivative and a vector's differential with symbolic components.

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

$\label{lem:decomposition} $$\operatorname{DervectdotsDvect}(\langle kernel1\rangle) = (\langle indvar\rangle) = (\langle kernel2\rangle) $$$

Identical to \dervectdotsdvect but uses Δ .

\DervectdotsDvect{A}{t}{B}

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

$\derivectdotedvect{\langle kernel1 \rangle}{\langle indvar \rangle}{\langle kernel2 \rangle}$

Dot of a vector's derivative and a vector's differential as an expanded sum.

\dervectdotedvect{A}{t}{B}

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

$\label{lem:decomposition} $$\operatorname{DervectdoteDvect}(\langle kernel1\rangle) = (\langle indvar\rangle) = (\langle kernel2\rangle) $$$

Identical to \dervectdotedvect but uses Δ .

\DervectdoteDvect{A}{t}{B}

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

$\derivectdotsdpos\{\langle kernel \rangle\}\{\langle indvar \rangle\}$

Dot of a vector's derivative and a position vector's differential with symbolic components.

\dervectdotsdpos{A}{t}

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

$\verb|\DervectdotsDpos|| \langle kernel \rangle \} \{ \langle indvar \rangle \}$

Identical to \dervectdotsdpos but uses Δ .

\DervectdotsDpos{A}{t}

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

$\dervectdotedpos\{\langle kernel \rangle\}\{\langle indvar \rangle\}$

Dot of a vector's derivative and a position vector's differential as an expanded sum.

 $\verb|\dervectdotedpos{A}{t}|$

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

$\verb|\DervectdoteDpos|| \{\langle kernel \rangle\} \{\langle indvar \rangle\}|$

Identical to \dervectdotedpos but uses Δ .

 $\verb|\DervectdoteDpos{A}{t}|$

$$\frac{\Delta A_{x}}{\Delta t}\Delta x + \frac{\Delta A_{y}}{\Delta t}\Delta y + \frac{\Delta A_{z}}{\Delta t}\Delta z$$

5.7.8 Expressions Containing Crosses

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

 $\ensuremath{\mbox{vectcrossvect}\{\langle kernel1\rangle\}\{\langle kernel2\rangle\}}$

Cross of two vectors.

 $ec{r} imesec{p}$

 $\label{eq:linear_loss} $$ \ \langle kernel1 \rangle = {\langle kernel2 \rangle} {\langle kernel3 \rangle} $$$

Symbol for left associated triple cross product.

\ltriplecross{\vect{A}}}{\vect{B}}}{\vect{C}}

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

 $\triplecross{\langle kernel1 \rangle}{\langle kernel2 \rangle}{\langle kernel2 \rangle}$

Symbol for right associated triple cross product.

\rtriplecross{\vect{A}}}{\vect{B}}}{\vect{C}}

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

 $\label{eq:limits} $$ \underset{\label{eq:limits}}{\text{ltriplescalar}} {\langle kernel1 \rangle} {\langle kernel2 \rangle} {\langle kernel3 \rangle} $$$

Symbol for left associated triple scalar product.

\ltriplescalar{\vect{A}}{\vect{B}}}{\vect{C}}

 $\vec{A} \times \vec{B} \bullet \vec{C}$

 $\mathsf{rtriplescalar}(\langle kernel1 \rangle) \{\langle kernel2 \rangle\} \{\langle kernel3 \rangle\}$

Symbol for right associated triple scalar product.

\rtriplescalar{\vect{A}}{\vect{B}}}{\vect{C}}

 $\vec{A} \bullet \vec{B} \times \vec{C}$

5.7.9 Basis Vectors and Bivectors

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

\ezero

Symbols for basis vectors with lower indices up to 4.

\ezero \eone \etwo \ethree \efour	$\mathbf{e} \underset{0}{\mathbf{e}} \mathbf{e} \underset{2}{\mathbf{e}} \underset{3}{\mathbf{e}} \mathbf{e}$
-----------------------------------	---

\uezero

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

\uezero \ueone \uetwo \uethree \uefour	$\hat{\mathbf{e}}_{0}$ $\hat{\mathbf{e}}_{1}$ $\hat{\mathbf{e}}_{2}$ $\hat{\mathbf{e}}_{3}$ $\hat{\mathbf{e}}_{4}$
--	--

\ezerozero

Symbols for basis bivectors with lower indices up to 4.

\ezerozero \ezeroone \ezerotwo \ezerothree ? \(\(\) \ezerofour \equiv \efourfour \)	$\mathbf{e}_{00\ 01}\mathbf{e}_{02\ 03\ 04}\mathbf{e}_{04}$ up to \mathbf{e}_{44}
--	---

\euzero

Symbols for basis vectors with upper indices up to 4.

\euzero \euone \eutwo \euthree \eufour	$\begin{smallmatrix}0&1&2&3&4\\\mathbf{e}&\mathbf{e}&\mathbf{e}&\mathbf{e}\end{smallmatrix}$
--	--

\euzerozero

Symbols for basis bivectors with upper indices up to 4.

\euzerozero \euzeroone \euzerotwo \euzerothree ?	${f e} \ {f e} \ {$
--	---

\gzero

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

\gzero \gone \gtwo \gthree \gfour	$\gamma_0^{}\gamma_1^{}\gamma_2^{}\gamma_3^{}\gamma_4^{}$

Allow for superscripts.

\guzero

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

\guzero \guone \gutwo \guthree \gufour $\gamma^0 \gamma^1 \gamma^2 \gamma^3 \gamma^4$

\gzerozero

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

\gzerozero \gzerotwo \gzerothree \gamma \qquad \gamma_{00} \gamma_{01} \gamma_{02} \gamma_{03} \gamma_{04} \text{up to } \gamma_{44} \qquad \qqqq \qqq \qqqq \qqq \qqqq \qqq \qqqq \qqq \qqqq \qqq \qqqq \qqq \qqqq \qqq \qqqq \qqq \qqqq \q

\guzerozero

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

\guzerozero \guzerotwo \guzerothree \gamma \quad \qua

$\colvector{\langle commadelimited list of comps \rangle}$

Typesets column vectors.

 $\colvector{\msup{x}{0},\msup{x}{1},\msup{x}{2}, \qquad \begin{pmatrix} x \\ x \\ x \\ x \end{pmatrix}$

$\commadelimited list of comps$

Typesets row vectors.

$\scompscvect[\langle anynonzero \rangle] \{\langle kernel \rangle\}$

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

$$\vec{p} = \begin{pmatrix} p_1 \\ p_2 \\ p_3 \end{pmatrix}$$
 \vect{p} &= \scompscvect{p} \\ vect{p} &= \scompscvect[4]{p} \end{align*}
$$\vec{p} = \begin{pmatrix} p_0 \\ p_1 \\ p_2 \\ p_3 \end{pmatrix}$$

 $\scompsrvect[\langle anynonzero \rangle] \{\langle kernel \rangle\}$

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

5.8 Physical Constants

5.8.1 Defining Physical Constants

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

Using this command causes several things to happen.

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

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

None of these commands takes any arguments.

5.8.2 Predefined Physical Constants

\oofpez

Coulomb constant.

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

\oofpezcs

Alternate form of Coulomb constant.

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

\vacuumpermittivity

Vacuum permittivity.

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

\mzofp

Biot-Savart constant.

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

\vacuumpermeability

Vacuum permeability.

\(\vacuumpermeabilitymathsymbol \approx \)
$$\mu_{\rm o} \approx 4\pi \times 10^{-7} \, {\rm T\cdot m/A}$$

\boltzmann

Boltzmann constant.

\(\boltzmannmathsymbol \approx \boltzmann\)	$k_{_{\mathrm{B}}}\approx1.3806\times10^{-23}\mathrm{J/K}$
---	--

\boltzmanninev

Alternate form of Boltlzmann constant.

\(\boltzmanninevmathsymbol \approx \begin{array} \(\boltzmanninev \)	$k_{_{\mathrm{B}}} \approx 8.6173 \times 10^{-5} \mathrm{eV/K}$
---	--

\stefan

Stefan-Boltzmann constant.

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

\planck

Planck constant.

\(\planckmathsymbol \approx \planck\)	$h \approx 6.6261 \times 10^{-34} \mathrm{J \cdot s}$
---------------------------------------	---

\planckinev

Alternate form of Planck constant.

\(\planckmathsymbol \approx \planckinev\)	$h \approx 4.1357 \times 10^{-15} \mathrm{eV \cdot s}$
---	---

\planckbar

Reduced Planck constant (Dirac constant).

\(\planckbarmathsymbol \approx \planckbar\)	$\hbar \approx 1.0546 \times 10^{-34} \mathrm{J \cdot s}$
---	--

\planckbarinev

Alternate form of reduced Planck constant (Dirac constant).

\(\planckbarmathsymbol \approx \planckbarinev\)	$\hbar \approx 6.5821 \times 10^{-16} \mathrm{eV \cdot s}$
---	---

\planckc

Planck constant times light speed.

\(\planckcmathsymbol \approx \planckc\)	$hc \approx 1.9864 \times 10^{-25} \mathrm{J\cdot m}$
---	---

\planckcinev

Alternate form of Planck constant times light speed.

\(\planckcinevmathsymbol \approx \planckcinev\)	$hc \approx 1.9864 \times 10^{-25} \mathrm{eV} \cdot \mathrm{nm}$
---	---

\rydberg

Rydberg constant.

\(\rydbergmathsymbol \approx \rydberg\)	$R_{\infty} \approx 1.0974 \times 10^7 \mathrm{m}^{-1}$
---	---

\bohrradius

Bohr radius.

\(\bohrradiusmathsymbol \approx \bohrradius\)	$a_0 \approx 5.2918 \times 10^{-11} \mathrm{m}$
---	---

\finestructure

Fine structure constant.

\(\finestructuremathsymbol \approx) (\finestructure\)	$\alpha \approx 7.2974 \times 10^{-3}$
--	--

\avogadro

Avogadro constant.

\(\avogadromathsymbol \approx \avogadro\)	$N_{\rm A} \approx 6.0221 \times 10^{23} \rm mol^{-1}$
---	---

\universalgrav

Universal gravitational constant.

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

\surfacegravfield

Earth's surface gravitational field strength.

\(\surfacegravfieldmathsymbol \approx) (\surfacegravfield\)	$gpprox 9.80\mathrm{m/s^2}$
--	-----------------------------

\clight

Magnitude of light's velocity (photon constant).

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

\clightinfeet

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

|--|

\Ratom

Approximate atomic radius.

\(\Ratommathsymbol \approx \Ratom\)	$r_{\rm atom} \approx 10^{-10} \rm m$
-------------------------------------	--

\Mproton

Proton mass.

\(\Mprotonmathsymbol \approx \Mproton\)	$m_{_{\mathrm{proton}}} pprox 1.6726 imes 10^{-27} \mathrm{kg}$
---	--

\Mneutron

Neutron mass.

\(\Mneutronmathsymbol \approx \Mneutron\)	$m_{_{\rm neutron}} \approx 1.6749 \times 10^{-27} {\rm kg}$
---	--

\Mhydrogen

Hydrogen atom mass.

\(\Mhydrogenmathsymbol \approx \Mhydrogen\)	$m_{_{\rm hydrogen}} \approx 1.6737 \times 10^{-27} \rm kg$
---	--

\Melectron

Electron mass.

\(\Melectronmathsymbol \approx \Melectron\)	$m_{_{\rm electron}} \approx 9.1094 \times 10^{-31} {\rm kg}$
---	--

\echarge

Elementary charge quantum.

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

\Qelectron

Electron charge.

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

\qelectron

Alias for \Q electron.

\Qproton

Proton charge.

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

\qproton

Alias for \Q proton.

\MEarth

Earth's mass.

\MMoon

Moon's mass.

\(\MMoonmathsymbol \approx \MMoon\)	$M_{_{\rm Moon}}\approx7.3459\times10^{22}{\rm kg}$
-------------------------------------	---

\MSun

Sun's mass.

\(\MSunmathsymbol \approx \MSun\)	$M_{_{\mathrm{Sun}}}\approx 1.9891\times {10}^{30}\mathrm{kg}$
-----------------------------------	--

\REarth

Earth's radius.

\(\REarthmathsymbol \approx \REarth\)	$R_{_{\mathrm{Earth}}} pprox 6.3675 imes 10^6 \mathrm{m}$
---------------------------------------	---

\RMoon

Moon's radius.

\(\RMoonmathsymbol \approx \RMoon\)	$R_{ ext{Moon}} \approx 1.7375 \times 10^6 ext{m}$
-------------------------------------	--

\RSun

Sun's radius.

\(\RSunmathsymbol \approx \RSun\)	$R_{\rm Sun} \approx 6.9634 \times 10^8 \mathrm{m}$
-----------------------------------	--

\ESdist

Earth-Sun distance.

\(\ESdistmathsymbol \approx \SEdist\)	$\left \vec{r}_{\mathrm{ES}} \right pprox 1.4960 imes 10^{11} \mathrm{m}$
---------------------------------------	--

\SEdist

Alias for \ESdist.

\EMdist

Earth-Moon distance.

\(\EMdistmathsymbol	\approx \EMdist\)	$\left \vec{r}_{\scriptscriptstyle ext{EM}} \right pprox 3.8440 imes 10^8 ext{m}$

\MEdist

Alias for $\backslash \texttt{EMdist}$.

5.9 Astronomical Constants and Quantities

\LSun

Sun's luminosity.

$L_{_{\rm Sun}}\approx 3.8460\times 10^{26}{\rm J/s}$

\TSun

Sun's effective temperature.

\(\TSunmathsymbol \approx \TSun\)	$T_{_{\mathrm{Sun}}}\approx5778\mathrm{K}$	

\MagSun

Sun's absolute magnitude.

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

\mbox{magSun}

Sun's apparent magnitude.

\(\magSunmathsymbol \approx \magSun\)	$m_{_{\rm Sun}}\approx -26.74$
---------------------------------------	--------------------------------

$\operatorname{Lstar}[\langle object \rangle]$

Symbol for stellar luminosity.

\Lstar \Lstar[Sirius]	$L_{\star}L_{ m Sirius}$
-----------------------	--------------------------

\Lsolar

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

\Lsolar	L_{\odot}	
---------	-------------	--

$\texttt{\Tstar}[\langle object \rangle]$

Symbol for stellar temperature.

\Tstar \Tstar[Sirius]	$T_{\star}T_{_{ m Sirius}}$
-----------------------	-----------------------------

\Tsolar

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

\Tsolar	T_{\odot}	
---------	-------------	--

$\Rstar[\langle object \rangle]$

Symbol for stellar radius.

\Rstar \Rstar[Sirius]	$R_{\star}R_{_{ m Sirius}}$
-----------------------	-----------------------------

\Rsolar

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

${\bf Nsolar} \hspace{1cm} R_{\odot}$	
---------------------------------------	--

$\Messar[\langle object \rangle]$

Symbol for stellar mass. $\,$

\Mstar \Mstar[Sirius]	$M_{\star}M_{ m Sirius}$
-----------------------	--------------------------

\Msolar

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

\Msolar	M_{\odot}

$\texttt{ar{Fstar}}[\langle object \rangle]$

Symbol for stellar flux.

\Fstar \Fstar[Sirius]	$F_{\star}F_{ m Sirius}$
-----------------------	--------------------------

\Fsolar

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

\Fsolar F_{\odot}	
---------------------	--

\fstar

Alias for \P

\fsolar

Alias for $\footnote{interpolate}$.

$\lceil (object) \rceil$

Symbol for stellar absolute magnitude.

\Magstar \Magstar[Sirius]	$M_{\star}M_{ m Sirius}$
---------------------------	--------------------------

\Magsolar

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

\Magsolar	M_{\odot}
-----------	-------------

$\mbox{\mbox{\tt magstar}} [\langle object \rangle]$

Symbol for stellar apparent magnitude.

\magstar	\magstar[Sirius]	

$$m_{_{\star}}\,m_{_{\rm Sirius}}$$

\magsolar

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

\ma	gs	ol	ar

$$m_{_{\bigodot}}$$

$\operatorname{Dstar}[\langle object \rangle]$

Symbol for stellar distance.

\ Datar	\ Datar	[Sirius]
(DStar	(DS Car	ISTITUSI

$$D_{\star}\,D_{_{\rm Sirius}}$$

\Dsolar

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

,	\Ds	01	aı



\dstar

Alias for \Dstar that uses a lower case d.

\dsolar

Alias for \Dsolar that uses a lower case d.

5.10 Frequently Used Fractions

\onehalf

Small fractions with numerator 1 and denominators up to 10.

\(\onehalf \cdots \on

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

\twooneths

Small fractions with numerator 2 and denominators up to 10.

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

\threeoneths

Small fractions with numerator 3 and denominators up to 10.

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

$\lceil (magnitude) \rceil$

Small fractions with numerator 4 and denominators up to 10.

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

5.11 Calculus

$\dx{\langle variable \rangle}$

Properly typesets variables of integration (the d should not be in italics and should be properly spaced relative to the integrand).

$\verb|\evalfromto|{|}\langle antiderivative|\rangle \} \{\langle lower|\rangle \} \{\langle upper|\rangle \}$

Properly typesets the evaluation of definite integrals.

\(\evalfromto{\onethird y^3}{0}{3}\\) $\left.\frac{1}{3}y^3\right|_0^3$

$\operatorname{\mathtt{\baseline}} \{\langle expression \rangle\} \{\langle evaluation point \rangle\}$

Properly typesets quantities evaluated at a particular point or value.

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

$\ensuremath{\ \ \ }$

Properly indicates evaluation at a particular point or value without specifying the quantity.

\(\mbox{LMST}\evaluatedat{\longitude{0}} \) LMST $_{0} \circ$

 $\integral [\langle lower \rangle] [\langle upper \rangle] {\langle integrand \rangle} {\langle var \rangle}$

Typesets indefinite and definite integrals.

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

 $\label{lower} $$ \prod_{\langle lower \rangle} [\langle upper \rangle] {\langle integrand \rangle} {\langle var \rangle} $$$

Typesets indefinite and definite integrals.



 $\operatorname{\operatorname{\mathsf{Nopensurfintegral}}} \langle \operatorname{\mathit{surfacename}} \rangle \} \{\langle \operatorname{\mathit{vectorname}} \rangle \}$

Integral over an open surface of the normal component of a vector field.

\[\opensurfintegral{S}{E} \] $\int_S \vec{E} \bullet \widehat{n} \, \mathrm{d}A$

 $\operatorname{\operatorname{\mathtt{NopensurfIntegral}}} \langle \operatorname{\mathit{surfacename}} \rangle \} \{\langle \operatorname{\mathit{vectorname}} \rangle \}$

Integral over an open surface of the normal component of a vector field.

\[\opensurfIntegral{S}{E} \] $\int_{\mathbf{S}} \vec{E} \bullet \hat{n} \, \mathrm{d}A$

$\cline{closedsurfintegral} {\langle surfacename \rangle} {\langle vectorname \rangle}$

Integral over a closed surface of the normal component of a vector field.

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

$$\oint_{S} \vec{E} \bullet \hat{n} \, dA$$

$\cline{closedsurfIntegral} {\langle surfacename \rangle} {\langle vectorname \rangle}$

Integral over a closed surface of the normal component of a vector field.

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

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

$\operatorname{\operatorname{\backslash}openlineintegral}\{\langle pathname \rangle\}\{\langle vectorname \rangle\}$

Integral over an open path of the tangential component of a vector field.

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

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

$\operatorname{\operatorname{\oopenlineIntegral}} \{\langle pathname \rangle\} \{\langle vectorname \rangle\}$

Integral over an open path of the tangential component of a vector field.

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



$\cline{closedline} (pathname) {(vectorname)}$

Integral over a closed path of the tangential component of a vector field.

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

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

$\cline{line} {\cline} {\clin$

Integral over a closed path of the tangential component of a vector field.



For line integrals, I have not employed the common $d\vec{\ell}$ symbol. Instead, I use $\hat{t} d\ell$ 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.

$\delta dbydt [\langle operand \rangle]$

First time derivative operator. Use \DbyDt to get Δ instead of d.

\(\dbydt \) or \(\dbydt x \) or \\dbydt[x]
$$\qquad \qquad \frac{\mathrm{d}}{\mathrm{d}t} \text{ or } \frac{\mathrm{d}}{\mathrm{d}t}x \text{ or } \frac{\mathrm{d}x}{\mathrm{d}t}$$

Second time derivative operator. Use \DDbyDt to get Δ instead of d.

\(\ddbydt \) or \(\ddbydt x \) or \\ddbydt[x]
$$\qquad \qquad \frac{\mathrm{d}^2}{\mathrm{d}t^2} \text{ or } \frac{\mathrm{d}^2x}{\mathrm{d}t^2}$$

\pbypt[\langle operand \rangle]

First partial time derivative operator.

\(\pbypt \) or \(\pbypt x \) or \pbypt[x]
$$\frac{\partial}{\partial t} \text{ or } \frac{\partial}{\partial t} x \text{ or } \frac{\partial x}{\partial t}$$

Second partial time derivative operator.

\(\ppbypt \) or \(\ppbypt x \) or \ppbypt[x]
$$\frac{\partial^2}{\partial t^2} \text{ or } \frac{\partial^2}{\partial t^2} x \text{ or } \frac{\partial^2 x}{\partial t^2}$$

$\delta dbyd{\langle dependent variable \rangle} {\langle ind var \rangle}$

Generic first derivative operator. Use \DbyD to get Δ instead of d.

\(\dbyd{f}{\dy}\)
$$\frac{\mathrm{d}f}{\mathrm{d}y}$$

	(dependent va	$riable \rangle \} \{ e$	(indvar))]
--	---------------	--------------------------	----------	----

Generic second derivative operator. Use \DDbyD to get Δ instead of d.

\(\ddbyd{f}{\dy^2}\) $\frac{\mathrm{d}^2 f}{\mathrm{d}y^2}$	
---	--

$\verb|\pbyp{| \langle dependent variable \rangle} {\langle ind var \rangle}|$

Generic first partial derivative operator.

\(\pbyp{f}{y} \)	$rac{\partial f}{\partial y}$
-------------------	--------------------------------

$\verb|\ppbyp|{|\langle dependent variable\rangle|} | |\langle ind var\rangle||$

Generic second partial derivative operator.

\(\ppbyp{f}{y} \)	$rac{\partial^2 f}{\partial y^2}$
--------------------	------------------------------------

\gradient

Gradient operator.

ackslashgradient	
------------------	--

\divergence

Divergente operator.

\divergence	ablaullet
-------------	-----------

\curl

Curl operator.

\laplacian

Laplacian operator.

	_		_	
\1	ap.	Lac	ia	an

∇^2

\dalembertian

D'Alembertian operator.

\dalembertian

\seriesfofx

Series expansion of f(x) around x = a.

\seriesfofx

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

\seriesexpx

Series expansion of e^x .

\seriesexpx

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

\seriessinx

Series expansion of $\sin x$.

\seriessinx

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

\seriescosx

Series expansion of $\cos x$.

\seriescosx

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

\seriestanx

Series expansion of $\tan x$.

\seriestanx
/per reprent

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

\seriesatox

Series expansion of a^x .

\seriesatox

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

\serieslnoneplusx

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

\serieslnoneplusx

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

\binomialseries

Series expansion of $(1+x)^n$.

\binomialseries

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

$\displaystyle \operatorname{diracdelta} \{\langle arg \rangle\}$

Dirac delta function.

\diracdelta{x}

$\delta(x)$

5.12 Other Useful Commands

\asin

Symbol for inverse sine and other inverse circular trig functions.

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

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

\sech

Hyperbolic and inverse hyperbolic functions not defined in LATEX.

\(\sech \csch \asinh \acosh \atanh \asech \)
\(\acosh \acoth \)

 $\mathrm{sech}\,\mathrm{csch}\,\mathrm{sinh}^{\text{-}1}\,\mathrm{cosh}^{\text{-}1}\,\mathrm{tanh}^{\text{-}1}\,\mathrm{sech}^{\text{-}1}\,\mathrm{csch}^{\text{-}1}\,\mathrm{coth}^{\text{-}1}$

 $\sl (arg)$

Signum function.

\(\sgn \)

\dex

Decimal exponentiation function (used in astrophysics).

\(\dex \) dex

 $\lceil \log b [\langle base \rangle]$

Logarithm to an arbitrary base.

 $\label{eq:logb_log_2} \log 8 \log_2 8$

\cB

Alternate symbol for magnetic field inspired by Tom Moore.

\cB \vect{\cB} $B ec{B}$

\newpi

Bob Palais' symbol for 2π .

\newpi π

Command to get fonts in Griffith's electrodynamics textbook.

\scripty{r} *

$\lceil \lfloor (label) \rceil$

Symbol for flux of a vector field.

\flux \flux[E]	$\Phi\Phi_{_{ m E}}$
----------------	----------------------

$\abs{\langle arg \rangle}$

Absolute value function.

	\abs{-4}	-4	
ı			

$\mbox{\mbox{$\backslash$ magof} } \{\langle arg \rangle\}$

Magnitude of a quantity (lets you selectively use double bars without setting the **doubleabsbars** option).

$\label{lem:magof} $$\max_{\mathbb{E}}$$	$\left\ ec{E} ight\ $

$\displaystyle \operatorname{\dimsof}\{\langle arg \rangle\}$

Notation for showing the dimensions of a quantity.

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

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.

<pre>\unitsof{\vect{v}} = \velocityonlytradunit</pre>	$\left[ec{v} ight]_u = \mathrm{m/s}$

$\operatorname{\mathsf{Quant}}\{\langle \mathit{arg}\rangle\}$

Surrounds the argument with variable sized parentheses. Use \bquant to get square brackets.

\quant{\oofpez}	$\left(8.9876 \times 10^{9} \mathrm{N \cdot m^{2}/C^{2}}\right)$
-----------------	--

Nnotation for the change in a quantity.

$\label{lem:change} $$ \operatorname{Changein}_{\operatorname{E}}$$	$\Delta ec{E}$

$\sin [\langle mantissa \rangle] \{\langle exponent \rangle\} [\langle unit \rangle]$

Command for scientific notation with an optional unit.

\scin[2.99]{8}[\velocityonlytradunit]	$2.99\times10^8~\mathrm{m/s}$
---------------------------------------	-------------------------------

$\ensuremath{\mbox{\rm ee}} \{\langle mantissa \rangle\} \{\langle exponent \rangle\}$

Command for scientific notation for computer code. Use \EE for EE.

\ee{2.99}{8}	2.99e8
--------------	--------

$\dms{\langle deg \rangle}{\langle min \rangle}{\langle sec \rangle}$

Command for formatting angles and time. Use \hms for time. Note that other packages may do this better.

\dms{23}{34}{10.27} \\ \hms{23}{34}{10.27}	23°34'10.27'' $23h34m10.27s$
--	------------------------------

$\cline{clockreading} \{\langle hrs \rangle\} \{\langle min \rangle\} \{\langle sec \rangle\}$

Command for formatting a clock reading. Really an alias for \hms, but conceptually a very different idea that introductory textbooks don't do a good enough job at articulating.

\clockreading{23}{34}{10.27}	$23^{\rm h}34^{\rm m}10.27^{\rm s}$
------------------------------	-------------------------------------

Command for formatting latitude, useful in astronomy. Use \latitudeN or \latitudeS to include a letter.

\latitude{+35} \latitudeN{35} \latitudeS{35}	+35° 35° N 35° S
--	------------------

$\label{arg} \$

Command for formatting longitude, useful in astronomy. Use \longitudeE or \longitudeW to include a letter.

\longitude{-81} \longitudeE{81} \longitudeW{81}	-81° 81 $^{\circ}$ E 81 $^{\circ}$ W
---	---

$\sideset{sup}{\langle kernel \rangle}{\langle sup \rangle}$

Command for typesetting text superscripts.

\ssup{N}{contact}	$\stackrel{ ext{contact}}{N}$
-------------------	-------------------------------

Command for typesetting text subscripts.

\ssub{N}{AB}	$N^{}_{ m AB}$	
	AB	

$\sum {\langle sup \rangle} {\langle sub \rangle}$

Command for typesetting text superscripts and subscripts.

\ssud{N}{contact}{AB}	$\stackrel{\rm contact}{N}_{\rm AB}$	
-----------------------	--------------------------------------	--

$\verb|\msup{} {\langle kernel \rangle} {\langle sup \rangle}$

Command for typesetting mathematical superscripts.

$\verb|\msub|{\langle kernel\rangle}|{\langle sub\rangle}|$

Command for typesetting mathematical subscripts.

$\label{eq:msub} $$\msub{R}_{\alpha}$$	$R_{lphaeta}$
--	---------------

$\mbox{\mbox{\mbox{$\backslash$}}} \{\langle sup \rangle\} \{\langle sub \rangle\}$

Command for typesetting mathematical superscripts and subscripts.

\msud{\Gamma}{\gamma}{\alpha\beta}	$\Gamma^{\gamma}_{m{lpha}eta}$	
------------------------------------	--------------------------------	--

Command for Levi-Civita symbol.

\levicivita{ijk}	$arepsilon_{ijk}$	

$\kronecker{\langle indices \rangle}$

Command for Kronecker delta symbol.

\kronecker{ij}	$\delta_{ij}^{}$
----------------	------------------

\xaxis

Command for coordinate axes.

$\nxis[\langle axis \rangle]$

Command for custom naming a coordinate axis.

\xyplane

Commands for naming coordinate planes. All combinations are defined.

\xyplane \yzplane \zxplane \zyplane \xzplane xy-plane yz-plane zx-plane zy-plane xz-plane

$\fsqrt{\langle arg \rangle}$

Command for square root as a fractional exponent.

\fsqrt{x}	$x^{rac{1}{2}}$
-----------	------------------

$\colon \colon \colon$

Command for cube root of an argument. Use \fcuberoot to get fractional exponent.

\cuberoot{x} \fcuberoot{x}	$\sqrt[3]{x} x^{\frac{1}{3}}$	
----------------------------	-------------------------------	--

$\footnote{\langle arg \rangle}$

Command for fourth root of an argument. Use \ffourthroot to get fractional exponent.

\fourthroot{x} \ffourthroot{x}	$\sqrt[4]{x}$ $x^{\frac{1}{4}}$
--------------------------------	---------------------------------

$\fifthroot{\langle arg \rangle}$

Command for fifth root of an argument. Use \ffifthroot to get fractional exponent.

\fifthroot{x} \ffifthroot{x}
$$\sqrt[5]{x} x^{\frac{1}{5}}$$

Expression for Lorentz factor. Use \frelgamma to get fractional exponent.

$\operatorname{losqrtomxs}\{\langle arg \rangle\}$

Commands for expressions convenient in numerically evaluating Lorentz factors. Say each expression out loud and you'll see where the command names come from.

$$\begin{array}{c} \text{\cosqrtomxs} \{0.22\} \\ \text{\cosqrtomx} \{0.22\} \\ \text{\coomx} \{0.22\} \\ \text{\coopx} \{0.11\} \end{array} \qquad \qquad \frac{1}{\sqrt{1-0.22^2}} \frac{1}{\sqrt{1-0.22}} \frac{1}{1-0.22} \frac{1}{1+0.11}$$

5.13 Custom Operators

The = operator is frequently misused, and we need other operators for other situations.

\isequals

Command for test-for-equality operator.

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

$\wordoperator{\langle firstline \rangle} {\langle second line \rangle}$

Command for two lines of tiny text to be use as an operator without using mathematical symbols. Use \pwordoperator to get parentheses around the operator.

```
\begin{tabular}{lll} $\operatorname{added} $& to \\ \operatorname{pwordoperator}_{added}_{to} $& ($^{added}_{to})$ \\ \end{tabular}
```

\definedas

Commands for frequently used word operators. Prepend p to each to get parentheses around the operator.

```
\definedas and \associated and \adjustedby \\
\earlierthan and \laterthan and \forevery \\
\pdefinedas and \passociated and \padjustedby \\
\pearlierthan and \padjustedby \\
\p
```

\defines

Command for defines or defined by operator.

```
\vect{p} \defines \(\gamma m\)\vect{v} ec p \stackrel{	ext{def}}{=} \gamma m ec v
```

\inframe [$\langle frame \rangle$]

Command for operator indicating the coordinate representation of a vector in a particular reference frame denoted by a capital letter.

\associates

Command for associated with or associates with operator (for verbal concepts).

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

\becomes

Command for *becomes* operator.

lem:lem:lem:lem:lem:lem:lem:lem:lem:lem:	$\gamma m ec{v} \xrightarrow{ ext{becomes}} m ec{v}$	
		J

Command for left-to-right relationship.

(flux ratio) \rrelatedto{taking logarithm} (mag) (flux ratio)
$$\xrightarrow{\text{taking logarithm}}$$
 (mag diff)

Command for right-to-left relationship.

(flux ratio) \lrelatedto{exponentiation} (mag) (diff)	$(flux \ ratio) \underset{exponentiation}{\longleftarrow} (mag \ diff)$
--	---

$\brightharpoonup \brightharpoonup \label{lem:brelatedto} $$ \brightharpoonup \align{center} \brightharpoonup \align{center}$

Command for bidirectional relationship.

$$(\text{mag diff}) \text{ brelatedto}\{\text{taking }\} \\ (\text{logarithm}\}\{\text{exponentiation}\}(\text{flux ratio})$$

5.14 Commands Specific to $Matter \ \mathcal{C}$ Interactions

\momentumprinciple

Expression for the momentum principle. Prepend \LHS to get just the left hand side and \RHS to get just the right hand side.

\momentumprinciple
$$ec{p}_{
m sys,i} = ec{p}_{
m sys,i} + ec{F}_{
m net,sys} \Delta t$$

\energyprinciple

Expression for the energy principle. Prepend \LHS to get just the left hand side and \RHS to get just the right hand side.

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

\angularmomentumprinciple

Expression for the angular momentum principle. Prepend \LHS to get just the left hand side and \RHS to get just the right hand side.

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

\gravitationalinteraction

Expression for gravitational interaction.

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

\electricinteraction

Expression for electric interaction.

$$\frac{1}{4\pi\epsilon_{\mathrm{o}}}\frac{Q_{_{1}}Q_{_{2}}}{\left|\vec{r}_{_{12}}\right|^{2}}\hat{r}_{_{12}}$$

\Efieldofparticle

Expression for a particle's electric field.

$$\frac{1}{4\pi\epsilon_{\mathrm{o}}}\frac{Q}{\left|\vec{r}\right|^{2}}\widehat{r}$$

\Bfieldofparticle

Expression for a particle's magnetic field.

\Bfieldofparticle	$rac{\mu_{\circ}}{4\pi} rac{Q\left ec{v} ight }{\left ec{r} ight ^{2}}\widehat{v} imes\widehat{r}$	
sys Symbol for system energy.		
\Esys	$E_{ m sys}$	
Symbol for spring potential energy.		
\Us	$U_{ m s}$	
g Symbol for gravitational potential energy.	$U_{ m g}$	
	$U_{ m g}$	
Symbol for gravitational potential energy. \Ug	$U_{ m g}$	
Symbol for gravitational potential energy. Ug e Symbol for electric potential energy.		

\Krot

 $K_{_{\mathrm{rot}}}$

۱r,	nn	~+	÷.	~7	-
15	Dа	ΙЬ	1	-1	. е
\ -	\sim		-	~-	. `

Symbol for particle energy.

\Eparticle	$E_{ m particle}$
------------	-------------------

\Einternal

Symbol for internal energy.

$\label{eq:einternal} E_{\text{internal}}$	
--	--

\Erest

Symbol for rest energy.

\Erest	$E_{ m rest}$
--------	---------------

\Echem

Symbol for chemical energy.

\Echem	$E_{ m chem}$
--------	---------------

\Etherm

Symbol for thermal energy.

	\Etherm	$E_{_{ m therm}}$	
٠,			

\Evib

Symbol for vibrational energy.

\Ephoton

Symbol for photon energy.

\Ephoton	$E_{ m photon}$
Symbol for change in spring potential energy.	
\DUs	$\Delta U_{ m s}$
OUg Symbol for change in gravitational potential energy	7.
\DUg	$\Delta U_{ m g}$
DUe	
Symbol for change in electric potential energy.	
	$\Delta U_{ m e}$
Symbol for change in electric potential energy.	$\Delta U_{ m e}$
Symbol for change in electric potential energy. \DUe OKtrans	$\Delta U_{ m e}$ $\Delta K_{ m trans}$
Symbol for change in electric potential energy. \DUe OKtrans Symbol for change in translational kinetic energy.	

\DEparticle

 $\Delta E_{\rm particle}$

\DEinternal

Symbol for change in internal energy.

\DEinternal	$\Delta E_{ m internal}$
-------------	--------------------------

\DErest

Symbol for change in rest energy.

\DErest	$\Delta E_{ m rest}^{}$
---------	-------------------------

\DEchem

Symbol for change in chemical energy.

\DEchem	$\Delta E_{_{\mathrm{chem}}}$
---------	-------------------------------

\DEtherm

Symbol for change in thermal energy.

\DEtherm	$\Delta E_{_{ m therm}}$	
----------	--------------------------	--

\DEvib

Symbol for change in vibrational energy.

\DEvib	$\Delta E_{ m vib}$
--------	---------------------

\DEphoton

Symbol for change in photon energy.

\DEphoton	$\Delta E_{ m photon}$
-----------	------------------------

\Usfinal

Expression for final spring potential energy.

	\Usfinal	$\left(rac{1}{2}k_{_{\mathrm{S}}}s^{2} ight)_{_{\mathrm{f}}}$	
--	----------	--	--

\Usinitial

Expression for initial spring potential energy.

\Usinitial	$\left(rac{1}{2}k_{_{\mathrm{s}}}s^{2} ight)_{_{\mathrm{i}}}$
------------	--

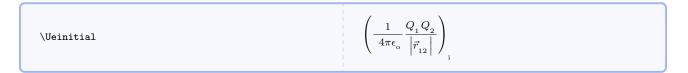
\Uefinal

Expression for final electric potential energy.

\Uefinal $ \left(\frac{1}{4\pi\epsilon_{\rm o}} \frac{Q_1^{} Q_2^{}}{\left \vec{r}_{\rm 12}^{} \right } \right)_{\rm f} $	
---	--

\Ueinitial

Expression for initial electric potential energy.



\Ugfinal

Expression for final gravitational potential energy.

\Ugfinal	$\left(-G\frac{M_1M_2}{\left \vec{r}_{12}\right }\right)_{\rm f}$
----------	---

\Uginitial

Expression for initial gravitational potential energy.

\Uginitial
$$\left(-G \frac{M}{\left| \vec{r}_{12} \right|} \right)_{i}$$

\ks

Symbol for spring stiffness.

\ks	$k_{_{ m S}}$	

\Fnet

Various symbols for net force.

```
\Fnet \Fnetext \Fnetsys \Fsub{ball,bat} ec{F}_{
m net}ec{F}_{
m net,ext}ec{F}_{
m net,sys}ec{F}_{
m ball,bat}
```

\Tnet

Various symbols for net torque.

```
\Tnet \Tnetext \Tnetsys \Tsub{ball,bat} ec{T}_{
m net} ec{T}_{
m net,sys} ec{T}_{
m net,sys} ec{T}_{
m ball,bat}
```

$\vert {vpythonline} {\langle vpythoncode \rangle}$

Command for a single line of VPython code used inline.

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

\begin{vpythonblock}

 $\langle environment\ content \rangle$

\end{vpythonblock}

Environment for a block of VPython code.

```
begin{vpythonblock}
  from visual import *
  sphere(center=pos(1,2,3),color=color.green)
  MyArrow=arrow(pos=earth.pos, axis=fscale*Fnet, color=color.green)
  print ("arrow.pos = "), arrow.pos
  \end{vpythonblock}

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

$\vert vpythonfile \langle filename \rangle$

Typesets a file in the current directory containing VPython code.

```
\vpythonfile{vdemo.py}
from __future__ import print_function, division
from visual import *
giant = sphere(pos=vector(-1e11,0,0)),radius=2e10,mass=2e30,color=color.red)
 giant.p = vector(0, 0, -1e4) * giant.mass
 dwarf = sphere(pos=vector(1.5el1,0,0)),radius=le10,mass=le30,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

```
\ensuremath{\mbox{\mbox{emptyanswer}}} [\langle wdth \rangle] [\langle hght \rangle]
```

Typesets empty space for filling answer boxes, so there is nothing to see.

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

```
\label{localization} $$ \left[ \left\langle bgclr \right\rangle \right] \left[ \left\langle frmclr \right\rangle \right] \left[ \left\langle txtclr \right\rangle \right] \left[ \left\langle wdth \right\rangle \right] \left[ \left\langle hght \right\rangle \right] \\ \left\langle environment\ content \right\rangle $$
```

\end{activityanswer}

Main environment for typesetting boxed answers.

```
\begin{activityanswer}
Lorem ipsum dolor sit amet, consectetuer adipiscing elit.
Morbi commodo, ipsum sed pharetra gravida, orci magna
rhoncus neque, id pulvinar odio lorem non turpis. Nullam
sit amet enim.
\end{activityanswer}
```

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

```
\begin{adjactivityanswer} [\langle bgclr \rangle] [\langle frmclr \rangle] [\langle txtclr \rangle] [\langle wdth \rangle] [\langle hght \rangle] \\ \langle environment\ content \rangle \\ \begin{adjactivityanswer} \end{adjactivityanswer} \end{adjactivityanswer} \\ \begin{adjactivityanswer} \end{adjactivityanswer} \end{adjactivityanswer} \\ \begin{adjactivityanswer} \end{adjactivityanswer} \end{adjactivityanswer} \end{adjactivityanswer} \end{adjactivityanswer} \\ \begin{adjactivityanswer} \end{adjactivityanswer} \end{adjactivityanswer} \end{adjactivityanswer} \\ \begin{adjactivityanswer} \end{adjactivityanswer} \end{adjactivityanswer} \end{adjactivityanswer} \\ \begin{adjactivityanswer} \end{adjactivityanswer} \end{adjactivityanswer} \end{adjactivityanswer} \\ \end{adjactivityanswer} \\ \end{adjactivityanswer} \end{adjactivityanswer} \\ \end{adjactivitya
```

Like \activityanswer but adjusts vertically to tightly surround text.

```
\begin{adjactivityanswer}
Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Morbi commodo, ipsum sed pharetra gravida, orci magna rhoncus neque, id pulvinar odio lorem non turpis. Nullam sit amet enim.
Suspendisse id velit vitae ligula volutpat condimentum. Aliquam erat volutpat. Sed quis velit. Nulla facilisi. Nulla libero.
Vivamus pharetra posuere sapien. Nam consectetuer. Sed aliquam, nunc eget euismod ullamcorper, lectus nunc ullamcorper orci, fermentum bibendum enim nibh eget ipsum. Donec porttitor ligula eu dolor. Maecenas vitae nulla consequat libero cursus venenatis. Nam magna enim, accumsan eu, blandit sed, blandit a, eros. \end{adjactivityanswer}
```

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Morbi commodo, ipsum sed pharetra gravida, orci magna rhoncus neque, id pulvinar odio lorem non turpis. Nullam sit amet enim. Suspendisse id velit vitae ligula volutpat condimentum. Aliquam erat volutpat. Sed quis velit. Nulla facilisi. Nulla libero. Vivamus pharetra posuere sapien. Nam consectetuer. Sed aliquam, nunc eget euismod ullamcorper, lectus nunc ullamcorper orci, fermentum bibendum enim nibh eget ipsum. Donec porttitor ligula eu dolor. Maecenas vitae nulla consequat libero cursus venenatis. Nam magna enim, accumsan eu, blandit sed, blandit a, eros.

```
\begin{tabular}{ll} \beg
```

Provides a fixed-size box with optional text.

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

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

 $\verb|\adjemptybox[|\langle txt\rangle]| [\langle bgclr\rangle]| [\langle frmclr\rangle]| [\langle txtclr\rangle]| [\langle wdth\rangle]| [\langle hght\rangle]|$

Like \emptybox but adjusts vertically to tightly surround text.

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

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

 $\verb|\answerbox| [\langle txt \rangle] [\langle bgclr \rangle] [\langle frmclr \rangle] [\langle txtclr \rangle] [\langle wdth \rangle] [\langle hght \rangle]$

Wrapper for \emptybox.

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

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

 $\adjanswerbox[\langle txt \rangle][\langle bgclr \rangle][\langle frmclr \rangle][\langle txtclr \rangle][\langle wdth \rangle][\langle hght \rangle]$

Wrapper for \adjemptybox.

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

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

$\mbox{\colored}(txt)$ [$\langle bgclr \rangle$]

Answer box with height 0.10 that of current \textheight and width 0.90 that of current \linewidth.



$\mbox{mediumanswerbox}[\langle txt \rangle][\langle bgclr \rangle]$

Answer box with height 0.20 that of current \textheight and width 0.90 that of current \linewidth.



$\lceil (txt) \rceil$

Answer box with height 0.25 that of current \textheight and width 0.90 that of current \linewidth (too large to show here).

\largeanswerbox[][lightgray]

$\lceil (txt) \rceil$

Answer box with height 0.33 that of current \textheight and width 0.90 that of current \linewidth (too large to show here).

\largeranswerbox[][lightgray]

$\hgensymbox[\langle txt \rangle][\langle bgclr \rangle]$

Answer box with height 0.50 that of current \textheight and width 0.90 that of current \linewidth (too large to show here).

\hugeanswerbox[][lightgray]

$\hggranswerbox[\langle txt angle][\langle bgclr angle]$

Answer box with height 0.75 that of current \textheight and width 0.90 that of current \linewidth (too large to show here).

\hugeranswerbox[][lightgray]

\fullpageanswerbox $[\langle txt \rangle]$ $[\langle bgclr \rangle]$

Answer box with height 1.00 that of current \textheight and width 0.90 that of current \linewidth (too large to show here).

\fullpageanswerbox[][lightgray]

\begin{miinstructornote}

 $\langle environment\ content \rangle$

\end{miinstructornote}

Environment for highlighting notes to instructors.

\begin{miinstructornote}

Nunc auctor bibendum eros. Maecenas porta accumsan mauris. Etiam enim enim, elementum sed, bibendum quis, rhoncus non, metus. Fusce neque dolor, adipiscing sed, consectetuer et, lacinia sit amet, quam. Suspendisse wisi quam, consectetuer in, blandit sed, suscipit eu, eros. Etiam ligula enim, tempor ut, blandit nec, mollis eu, lectus. Nam cursus. Vivamus iaculis. Aenean risus purus, pharetra in, blandit quis, gravida a, turpis. Donec nisl. Aenean eget mi. Fusce mattis est id diam. Phasellus faucibus interdum sapien. \end{miinstructornote}

INSTRUCTOR NOTE

Nunc auctor bibendum eros. Maecenas porta accumsan mauris. Etiam enim, elementum sed, bibendum quis, rhoncus non, metus. Fusce neque dolor, adipiscing sed, consectetuer et, lacinia sit amet, quam. Suspendisse wisi quam, consectetuer in, blandit sed, suscipit eu, eros. Etiam ligula enim, tempor ut, blandit nec, mollis eu, lectus. Nam cursus. Vivamus iaculis. Aenean risus purus, pharetra in, blandit quis, gravida a, turpis. Donec nisl. Aenean eget mi. Fusce mattis est id diam. Phasellus faucibus interdum sapien.

\begin{mistudentnote}

 $\langle environment\ content \rangle$

\end{mistudentnote}

Environment for highlighting notes to students.

\begin{mistudentnote}

Nunc auctor bibendum eros. Maecenas porta accumsan mauris. Etiam enim enim, elementum sed, bibendum quis, rhoncus non, metus. Fusce neque dolor, adipiscing sed, consectetuer et, lacinia sit amet, quam. Suspendisse wisi quam, consectetuer in, blandit sed, suscipit eu, eros. Etiam ligula enim, tempor ut, blandit nec, mollis eu, lectus. Nam cursus. Vivamus iaculis. Aenean risus purus, pharetra in, blandit quis, gravida a, turpis. Donec nisl. Aenean eget mi. Fusce mattis est id diam. Phasellus faucibus interdum sapien.

STUDENT NOTE

Nunc auctor bibendum eros. Maecenas porta accumsan mauris. Etiam enim enim, elementum sed, bibendum quis, rhoncus non, metus. Fusce neque dolor, adipiscing sed, consectetuer et, lacinia sit amet, quam. Suspendisse wisi quam, consectetuer in, blandit sed, suscipit eu, eros. Etiam ligula enim, tempor ut, blandit nec, mollis eu, lectus. Nam cursus. Vivamus iaculis. Aenean risus purus, pharetra in, blandit quis, gravida a, turpis. Donec nisl. Aenean eget mi. Fusce mattis est id diam. Phasellus faucibus interdum sapien.

 $\begin{miderivation}\\ \langle environment\ content \rangle\\ \end{miderivation}$

Environment for mathematical derivations based on the align environment.

```
\begin{miderivation}
  \gamma &= \relgamma{\magvect{v}}
    && \text{given} \\
  \msup{\gamma}{2}&= \ooomx{\msup{(\frac{\magvect{v}}{c})}{2}}
    &&\text{square both sides}\\
  \frac{1}{\msup{\gamma}{2}}&=1-\msup{(\frac{\magvect{v}}{c}))}{2}
    &&\text{reciprocal of both sides} \\
  \msup{(\frac{\magvect{v}}{c})}{2}&=1-\frac{1}{\msup{\gamma}{2}}
    &&\text{rearrange} \\
  \frac{\magvect{v}}{c}}{c}=\sqrt{1-\frac{1}{\infty p}{\alpha ma}}{2}}
    &&\text{square root of both sides}
\end{\miderivation}
```

DERIVATION

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

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

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

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

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

\begin{bwinstructornote}

 $\langle environment\ content \rangle$

\end{bwinstructornote}

Environment for highlighting notes to instructors.

\begin{bwinstructornote}

Nunc auctor bibendum eros. Maecenas porta accumsan mauris. Etiam enim enim, elementum sed, bibendum quis, rhoncus non, metus. Fusce neque dolor, adipiscing sed, consectetuer et, lacinia sit amet, quam. Suspendisse wisi quam, consectetuer in, blandit sed, suscipit eu, eros. Etiam ligula enim, tempor ut, blandit nec, mollis eu, lectus. Nam cursus. Vivamus iaculis. Aenean risus purus, pharetra in, blandit quis, gravida a, turpis. Donec nisl. Aenean eget mi. Fusce mattis est id diam. Phasellus faucibus interdum sapien.

INSTRUCTOR NOTE

Nunc auctor bibendum eros. Maecenas porta accumsan mauris. Etiam enim enim, elementum sed, bibendum quis, rhoncus non, metus. Fusce neque dolor, adipiscing sed, consectetuer et, lacinia sit amet, quam. Suspendisse wisi quam, consectetuer in, blandit sed, suscipit eu, eros. Etiam ligula enim, tempor ut, blandit nec, mollis eu, lectus. Nam cursus. Vivamus iaculis. Aenean risus purus, pharetra in, blandit quis, gravida a, turpis. Donec nisl. Aenean eget mi. Fusce mattis est id diam. Phasellus faucibus interdum sapien.

\begin{bwstudentnote}

Environment for highlighting notes to students.

\begin{bwstudentnote}

Nunc auctor bibendum eros. Maecenas porta accumsan mauris. Etiam enim enim, elementum sed, bibendum quis, rhoncus non, metus. Fusce neque dolor, adipiscing sed, consectetuer et, lacinia sit amet, quam. Suspendisse wisi quam, consectetuer in, blandit sed, suscipit eu, eros. Etiam ligula enim, tempor ut, blandit nec, mollis eu, lectus. Nam cursus. Vivamus iaculis. Aenean risus purus, pharetra in, blandit quis, gravida a, turpis. Donec nisl. Aenean eget mi. Fusce mattis est id diam. Phasellus faucibus interdum sapien.

STUDENT NOTE

Nunc auctor bibendum eros. Maecenas porta accumsan mauris. Etiam enim enim, elementum sed, bibendum quis, rhoncus non, metus. Fusce neque dolor, adipiscing sed, consectetuer et, lacinia sit amet, quam. Suspendisse wisi quam, consectetuer in, blandit sed, suscipit eu, eros. Etiam ligula enim, tempor ut, blandit nec, mollis eu, lectus. Nam cursus. Vivamus iaculis. Aenean risus purus, pharetra in, blandit quis, gravida a, turpis. Donec nisl. Aenean eget mi. Fusce mattis est id diam. Phasellus faucibus interdum sapien.

\begin{bwderivation}
⟨environment content⟩

\end{bwderivation}

Environment for mathematical derivations based on the align environment.

```
\begin{bwderivation}
  \gamma &= \relgamma{\magvect{v}}
  && \text{given} \\
  \msup{\gamma}{2}&= \ooomx{\msup{(\frac{\magvect{v}}{c}))}{2}}
  &&\text{square both sides}\\
  \frac{1}{\msup{\gamma}{2}}&=1-\msup{(\frac{\magvect{v}}{c}))}{2}
  &&\text{reciprocal of both sides} \\
  \msup{(\frac{\magvect{v}}{c}))}{2}&=1-\frac{1}{\msup{\gamma}{2}}
  &&\text{rearrange} \\
  \frac{\magvect{v}}{c}&=\sqrt{1-\frac{1}{\msup{\gamma}{2}}}
  &&\text{square root of both sides}
\end{bwderivation}
```

DERIVATION

$$\gamma = \frac{1}{\sqrt{1 - \left(\frac{|\vec{v}|}{c}\right)^2}}$$
 given
$$\gamma^2 = \frac{1}{1 - \left(\frac{|\vec{v}|}{c}\right)^2}$$
 square both sides
$$\frac{1}{\gamma^2} = 1 - \left(\frac{|\vec{v}|}{c}\right)^2$$
 reciprocal of both sides
$$\left(\frac{|\vec{v}|}{c}\right)^2 = 1 - \frac{1}{\gamma^2}$$
 rearrange
$$\frac{|\vec{v}|}{c} = \sqrt{1 - \frac{1}{c^2}}$$
 square root of both sides

5.16 Miscellaneous Commands

\checkpoint

Centered checkpoint for student discussion.

\checkpoint |----- CHECKPOINT -----|

 $\label{limited} $$ \sum_{\alpha \in \{(caption)\}} {(caption)} $$$

Centered figure displayed actual size with caption.

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

 \slash sneakyone $\{\langle thing \rangle\}$

Sshows factors dividing to a sneaky one.



5.17 Experimental Commands

Commands defined in this section are not guaranteed to work consistently and are included for experimental uses only. They may or may not exist in future releases. Most are an attempt to simplify existing commands for subscripted vectors.

Experimental Syntax		Existing Syntax
<pre>\vecto{E} \vecto{E}[ball] \compvecto{E}{y} \compvecto{E}{x}[ball]</pre>	$ec{E}_{ ext{ball}} \ ec{E}_{y} \ E$	<pre>\vect{E} \vectsub{E}{ball} \compvect{E}{y} \compvectsub{E}{x}{ball}</pre>
\scompsvecto{E}	$\left\langle E_{_{x}},E_{_{y}},E_{_{z}} ight angle$	\scompsvect{E}
\scompsvecto{E}[ball]	$\left\langle E_{x,\mathrm{ball}}, E_{y,\mathrm{ball}}, E_{z,\mathrm{ball}} \right\rangle$	\scompsvectsub{E}{ball}
\compposo{y} \compposo{y}[ball] \scompsposo	$y \ y_{ ext{ball}} \ \langle x,y,z angle$	<pre>\comppos{y} \comppossub{y}{ball} \scompspos</pre>
\scompsposo[ball]	$\left\langle x_{_{\mathrm{ball}}},y_{_{\mathrm{ball}}},z_{_{\mathrm{ball}}}\right\rangle$	\scompspossub{ball}

6 Source Code

45 \ProcessOptions\relax

```
Note the packages that must be present.
 1 \RequirePackage{amsmath}
 2 \RequirePackage{amssymb}
 3 \RequirePackage{array}
 4 \RequirePackage{bigints}
 5 \RequirePackage{cancel}
 6 \RequirePackage[dvipsnames] {xcolor}
 7 \RequirePackage{environ}
 8 \RequirePackage{etoolbox}
 9 \RequirePackage{filehook}
10 \RequirePackage{extarrows}
11 \RequirePackage[T1]{fontenc}
12 \RequirePackage{graphicx}
13 \RequirePackage{epstopdf}
14 \RequirePackage{textcomp}
15 \RequirePackage{letltxmacro}
16 \RequirePackage{listings}
17 \RequirePackage[framemethod=TikZ] {mdframed}
18 \RequirePackage{suffix}
19 \RequirePackage{xargs}
20 \RequirePackage{xparse}
21 \RequirePackage{xspace}
22 \RequirePackage{ifthen}
23 \RequirePackage{calligra}
24 \DeclareMathAlphabet{\mathcalligra}{T1}{calligra}{m}{n}
25 \DeclareFontShape{T1}{calligra}{m}{n}{<->s*[2.2]callig15}{}
26 \DeclareGraphicsRule{.tif}{png}{.png}{'convert #1 'basename #1 .tif'.png}
27 \DeclareMathAlphabet{\mathpzc}{OT1}{pzc}{m}{it}
28 \usetikzlibrary{shadows}
29 \definecolor{vpythoncolor}{rgb}{0.95,0.95,0.95}
{\tt 30 \ newcommand \{ lstvpython \} \{ lstset \{ language = Python, numbers = left, number style = \ tiny, numbers = left, number style = \ tiny, number = \ tiny
         backgroundcolor=\color{vpythoncolor},upquote=true,breaklines}}
32 \newcolumntype{C}[1]{>{\centering}m{#1}}
33 \newboolean{@optitalicvectors}
34 \newboolean{@optdoubleabsbars}
35 \newboolean{@optbaseunits}
36 \newboolean{@optdrvdunits}
37 \setboolean{@optitalicvectors}{false}
38 \setboolean{@optdoubleabsbars}{false}
39 \setboolean{@optbaseunits}{false}
40 \setboolean{@optdrvdunits}{false}
42 \DeclareOption{doubleabsbars}{\setboolean{@optdoubleabsbars}{true}}
43 \DeclareOption{baseunits}{\setboolean{@optbaseunits}{true}}
44 \DeclareOption{drvdunits}{\setboolean{@optdrvdunits}{true}}
```

```
This block of code fixes a conflict with the amssymb package.
46 \@ifpackageloaded{amssymb}{%
    \csundef{square}
    \typeout{mandi: Package amssymb detected. Its \protect\square\space has been redefined.}
48
49 }{%
   \typeout{mandi: Package amssymb not detected.}
50
51 }%
This block of code defines unit names and symbols.
52 \newcommand{\per}{\ensuremath{/}}
53 \newcommand{\usk}{\ensuremath{\cdot}}
54 \mbox{ } \{1\} \
55 \newcommand{\ampere}{\ensuremath{\mathrm{A}}}}
56 \newcommand{\arcminute}{\ensuremath{'}}
57 \newcommand{\arcsecond}{\ensuremath{''}}
58 \newcommand{\atomicmassunit}{\ensuremath{\mathrm{u}}}
59 \newcommand{\candela}{\ensuremath{\mathrm{cd}}}
60 \newcommand{\coulomb}{\ensuremath{\mathrm{C}}}
61 \newcommand{\degree}{\ensuremath{^{\circ}}}
62 \newcommand{\electronvolt}{\ensuremath{\mathrm{eV}}}
63 \newcommand{\eV}{\electronvolt}
64 \newcommand{\farad}{\ensuremath{\mathrm{F}}}
65 \newcommand{\henry}{\ensuremath{\mathrm{H}}}
66 \newcommand{\hertz}{\ensuremath{\mathrm{Hz}}}
67 \newcommand{\hour}{\ensuremath{\mathrm{h}}}
68 \newcommand{\joule}{\ensuremath{\mathrm{J}}}
69 \newcommand{\kelvin}{\ensuremath{\mathrm{K}}}
70 \newcommand{\kilogram}{\ensuremath{\mathrm{kg}}}
71 \newcommand{\metre}{\ensuremath{\mathrm{m}}}
72 \newcommand{\minute}{\ensuremath{\mathrm{min}}}
73 \newcommand{\mole}{\ensuremath{\mathrm{mol}}}
74 \mbox{newcommand{\newton}{\newton}{\newton}{\newton}{\newton}{\normalcommand{\newton}}}
75 \newcommand{\ohm}{\ensuremath{\Omega}}
76 \ensuremath{\mathbf{Pa}} 
77 \newcommand{\radian}{\ensuremath{\mathrm{rad}}}
78 \newcommand{\second}{\ensuremath{\mathrm{s}}}
79 \newcommand{\siemens}{\ensuremath{\mathrm{S}}}
80 \newcommand{\steradian}{\ensuremath{\mathrm{sr}}}
81 \newcommand{\tesla}{\ensuremath{\mathrm{T}}}
82 \newcommand{\volt}{\ensuremath{\mathrm{V}}}
83 \newcommand{\watt}{\ensuremath{\mathrm{W}}}
84 \newcommand{\weber}{\ensuremath{\mathrm{Wb}}}
85 \newcommand{\C}{\coulomb}
86 \newcommand{\F}{\farad}
87 %\H is already defined as a LaTeX accent
88 \newcommand{\J}{\joule}
89 \newcommand{\N}{\newton}
90 \newcommand{\Pa}{\pascal}
91 \newcommand{\rad}{\radian}
92 \newcommand{\sr}{\steradian}
93 %\S is already defined as a LaTeX symbol
```

```
94 \newcommand{\T}{\tesla}
  95 \newcommand{\V}{\volt}
  96 \newcommand{\W}{\watt}
  97 \newcommand{\Wb}{\weber}
                                                                                                                                                                                    % prefix
  98 \newcommand{\square}[1]{\ensuremath{\mathrm{#1}^{2}}}
  99 \newcommand*{\cubic}[1]{\ensuremath{\mathrm{#1}^{3}}}
                                                                                                                                                                                     % prefix
                                                                                                                                                                                                                3
 100 \newcommand*{\quartic}[1]{\ensuremath{\mathrm{#1}^{4}}}
                                                                                                                                                                                     % prefix
101 \newcommand*{\reciprocal}[1]{\ensuremath{\mathrm{#1}^{-1}}}
                                                                                                                                                                                     % prefix
102 \newcommand*{\reciprocalsquare}[1]{\ensuremath{\mathrm{#1}^{-2}}}
                                                                                                                                                                                    % prefix
103 \newcommand*{\reciprocalcubic}[1]{\ensuremath{\mathrm{#1}^{-3}}}
                                                                                                                                                                                    % prefix
104 \newcommand*{\reciprocalquartic}[1]{\ensuremath{\mathrm{#1}^{-4}}} % prefix -4
105 \newcommand*{\squared}{\ensuremath{^{\mathrm{2}}}}
                                                                                                                                                                                    % postfix 2
106 \newcommand*{\cubed}{\ensuremath{^{\mathrm{3}}}}
                                                                                                                                                                                    % postfix 3
107 \newcommand*{\quarted}{\ensuremath{^{\mathrm{4}}}}
                                                                                                                                                                                    % postfix 4
108 \newcommand*{\reciprocaled}{\ensuremath{^{\mathrm{-1}}}}
                                                                                                                                                                                    % postfix -1
109 \newcommand*{\reciprocalsquared}{\ensuremath{^{\mathrm{-2}}}}}
                                                                                                                                                                                    % postfix -2
110 \newcommand*{\reciprocalcubed}{\ensuremath{^{\mathrm{-3}}}}
                                                                                                                                                                                    % postfix -3
111 \mbox{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\command}{\com
                                                                                                                                                                                    % postfix -4
  Define a new named physics quantity or physical constant and commands for selecting units. My thanks to Ulrich
  Diez for contributing this code.
112 \newcommand\mi@exchangeargs[2]{#2#1}%
113 \newcommand\mi@name{}%
114 \long\def\mi@name#1#{\romannumeral0\mi@innername{#1}}%
115 \newcommand\mi@innername[2]{%
             \end{after} wi @exchange args \expand after {\csname #2 \end{sname} {\#1}} % where $\csname = \csname = \csname {\#1}} % where $\csname = \csname = \csname
117 \begingroup
118 \Ofirstofone{%
             \endgroup
119
             \newcommand\mi@forkifnull[3]{%
120
                  \romannumeral\iffalse{\fi\expandafter\@secondoftwo\expandafter
121
122
                  {\expandafter{\string#1}\expandafter\@secondoftwo\string}%
                  \expandafter\@firstoftwo\expandafter{\iffalse}\fi0 #3}{0 #2}}}%
123
124 \newcommand\selectbaseunit[3]{#1}
125 \newcommand\selectdrvdunit[3]{#2}
126 \newcommand\selecttradunit[3]{#3}
127 \newcommand\selectunit{}
128 \newcommand\perpusebaseunit{\let\selectunit=\selectbaseunit}
129 \newcommand\perpusedrvdunit{\let\selectunit=\selectdrvdunit}
130 \newcommand\perpusetradunit{\let\selectunit=\selecttradunit}
131 \newcommand\hereusebaseunit[1]{%
             \begingroup\perpusebaseunit#1\endgroup}%
132
133 \newcommand\hereusedrvdunit[1]{%
134
             \begingroup\perpusedrvdunit#1\endgroup}%
135 \newcommand\hereusetradunit[1]{%
             \begingroup\perpusetradunit#1\endgroup}%
137 \newenvironment{usebaseunit}{\perpusebaseunit}{}%
138 \newenvironment{usedrvdunit}{\perpusedrvdunit}{}%
139 \newenvironment{usetradunit}{\perpusetradunit}{}%
140 \newcommand*\newphysicsquantity{\definephysicsquantity{\newcommand}}
141 \newcommand*\redefinephysicsquantity{\definephysicsquantity{\renewcommand}}
```

```
142 \newcommandx\definephysicsquantity[5][4=,5=]{%
    \innerdefine what so ever quantity for k {#3} {#4} {#5} {#1} {#2} {} {[1]} {##1}}%
144 \newcommand*\newphysicsconstant{\definephysicsconstant{\newcommand}}
145 \newcommand*\redefinephysicsconstant{\definephysicsconstant{\renewcommand}}
146 \newcommandx\definephysicsconstant[7][6=,7=]{%
     \innerdefinewhatsoeverquantityfork{#5}{#6}{#7}{#1}{#2}{#3}{}{#4}}%
147
   \newcommand\innerdefinewhatsoeverquantityfork[3]{%
148
149
    \expandafter\innerdefinewhatsoeverquantity\romannumeral0%
150
    \mio(forkifnull{#3}{\min(forkifnull{#2}{{#1}}{{#2}}{#1})}
151
                   {\mi@forkifnull{#2}{{#1}}{{#2}}{#3}}{#1}}%
152 \newcommand\innerdefinewhatsoeverquantity[8]{%
    153
    154
    \mi@name#4{#5drvdunit}#7{\ensuremath{\unit{#8}{#1}}}%
155
    \miCname#4{\#5tradunit}\#7{\ensuremath{\unit{\#8}{\#2}}}%
156
    \mi@name#4{#5onlyunit}{\ensuremath{\selectunit{#3}{#1}{#2}}}%
157
    \mi@name#4{#5onlybaseunit}{\ensuremath{#3}}%
158
    \mi@name#4{#5onlydrvdunit}{\ensuremath{#1}}%
159
    \mi@name#4{#5onlytradunit}{\ensuremath{#2}}%
160
    \mi@name#4{#5value}#7{\ensuremath{#8}}%
161
    \mi@forkifnull{#7}{%
162
163
      \ifx#4\renewcommand\mi@name\let{#5mathsymbol}=\relax\fi
      \mi@name\newcommand{#5mathsymbol}{\ensuremath{#6}}}{}}%
164
This block of code processes the options.
165 \ifthenelse{\boolean{@optitalicvectors}}
166
    {\typeout{mandi: You'll get italic vector kernels.}}
    {\typeout{mandi: You'll get Roman vector kernels.}}
168 \ifthenelse{\boolean{@optdoubleabsbars}}
    {\typeout{mandi: You'll get double absolute value bars.}}
    {\typeout{mandi: You'll get single absolute value bars.}}
170
171 \ifthenelse{\boolean{@optbaseunits}}
172
    {\perpusebaseunit %
173
     \typeout{mandi: You'll get base units.}}
    {\ifthenelse{\boolean{@optdrvdunits}}
174
       {\perpusedrvdunit %
175
        \typeout{mandi: You'll get derived units.}}
176
177
       {\perpusetradunit %
        \typeout{mandi: You'll get traditional units.}}}
178
This block of code makes parentheses adjustable.
179 \def\resetMathstrut@{%
180
    \setbox\z@\hbox{%
181
      \mathchardef\@tempa\mathcode'\[\relax
      182
183
      \expandafter\@tempb\meaning\@tempa \relax}%
    184
    \catcode'(\active \xdef({\left\string(}
186
    \catcode')\active \xdef){\right\string)}
187
188 \endgroup
```

```
189 \mathcode'(="8000 \mathcode')="8000
190 \typeout{mandi: parentheses made adjustable in math mode.}
 This block of code fixes square root symbol.
191 \let\oldr@@t\r@@t
192 \def\r@@t#1#2{%
193 \ensuremath{\texttt{193} \ensuremath{\texttt{142},}})}\dimen0=\ht0}
194 \advance\dimen0-0.2\ht0
195 \setbox2=\hbox{\vrule height\ht0 depth -\dimen0}%
196 {\box0\lower0.4pt\box2}}
197 \LetLtxMacro{\oldsqrt}{\sqrt}
198 \renewcommand*{\sqrt}[2][\relax]{\oldsqrt[#1]{#2}}
199 \typeout{mandi: square root symbol fixed.}
 SI base unit of length or spatial displacement
200 \newcommand{\m}{\metre}
 SI base unit of mass
201 \newcommand{\kg}{\kilogram}
 SI base unit of time or temporal displacement
202 \newcommand{\s}{\second}
 SI base unit of electric current
203 \mbox{ \newcommand{\A}{\ampere}}
 SI base unit of thermodynamic temperature
204 \mbox{ }\mbox{wecommand{\K}{\kelvin}
 SI base unit of amount
205 \mbox{ } \mbox{mol}{\mbox{mole}}
 SI base unit of luminous intensity
206 \mbox{ \newcommand{\cd}{\candela}}
207 \newphysicsquantity{displacement}{\m}[\m][\m]
208 \newphysicsquantity{mass}{\kg}[\kg][\kg]
209 \newphysicsquantity{duration}{\s}[\s][\s]
210 \newphysicsquantity{current}{\A}[\A][\A]
211 \newphysicsquantity{temperature}{\K}[\K][\K]
212 \newphysicsquantity{amount}{\mol}[\mol][\mol]
213 \newphysicsquantity{luminous}{\cd}[\cd][\cd]
214 \newphysicsquantity{planeangle}{\m\usk\reciprocal\m}[\rad][\rad]
215 \newphysicsquantity{solidangle}{\m\squared\usk\reciprocalsquare\m}[\sr][\sr]
216 \newcommand{\indegrees}[1]{\ensuremath{\unit{#1}{\degree}}}
217 \newcommand{\inFarenheit}[1]{\ensuremath{\unit{#1}{\degree\mathrm{F}}}}}
218 \newcommand{\inCelsius}[1] {\ensuremath{\unit{#1}}{\degree\mathrm{C}}}}
219 \newcommand{\inarcminutes}[1]{\ensuremath{\unit{#1}{\arcminute}}}
220 \newcommand{\inarcseconds}[1]{\ensuremath{\unit{#1}{\arcsecond}}}}
221 \newcommand{\ineV}[1]{\ensuremath{\unit{#1}{\electronvolt}}}
222 \mbox{\ensuremath}_{\mbox{\ensuremath}}\
223 \newcommand{\inMeVoc}[1]{\ensuremath{\unit{#1}{\{\mathbb{WeV}\per c}}}
224 \newcommand{\inAU}[1]{\ensuremath{\unit{#1}{\mathbb{AU}}}}
225 \newcommand{\inly}[1]{\ensuremath{\unit{#1}{\mathrm{ly}}}}
```

```
226 \newcommand{\incyr}[1]{\ensuremath{\unit{#1}{c\usk\mathrm{year}}}}
227 \newcommand{\inpc}[1]{\ensuremath{\unit{#1}{\mathrm{pc}}}}
228 \newcommand{\insolarL}[1]{\ensuremath{\unit{#1}{\Lsolar}}}
229 \newcommand{\insolarT}[1]{\ensuremath{\unit{#1}{\Tsolar}}}
230 \newcommand{\insolarR}[1]{\ensuremath{\unit{#1}{\Rsolar}}}
231 \newcommand{\insolarM}[1]{\ensuremath{\unit{#1}{\Msolar}}}
232 \newcommand{\insolarF}[1]{\ensuremath{\unit{#1}{\Fsolar}}}
233 \newcommand{\insolarf}[1]{\ensuremath{\unit{#1}{\fsolar}}}
234 \newcommand{\insolarMag}[1]{\ensuremath{\unit{#1}}{\Magsolar}}}
235 \newcommand{\insolarmag}[1]{\ensuremath{\unit{#1}{\magsolar}}}
236 \newcommand{\insolarD}[1]{\ensuremath{\unit{#1}{\Dsolar}}}
237 \newcommand{\insolard}[1]{\ensuremath{\unit{#1}{\dsolar}}}
238 \newcommand{\velocityc}[1]{\ensuremath{#1c}}
240 \newphysicsquantity{acceleration}{\m\usk\s\reciprocalsquared}[\N\per\kg][\m\per\s\squared]
241 \newcommand{\lorentz}[1]{\ensuremath{#1}}
242 \newphysicsquantity{momentum}{\m\usk\kg\usk\reciprocal\s}[\N\usk\s][\kg\usk\m\per\s]
243 \newphysicsquantity{impulse}{\m\usk\kg\usk\reciprocal\s}[\N\usk\s][\kg\usk\m\per\s]
244 \newphysicsquantity{force}{\m\usk\kg\usk\s\reciprocalsquared}[\N][\N]
245 \newphysicsquantity{springstiffness}{\kg\usk\s\reciprocalsquared}[\N\per\m][\N\per\m]
246 \newphysicsquantity{springstretch}{\m}
247 \newphysicsquantity{area}{\m\squared}
248 \newphysicsquantity{volume}{\cubic\m}
249 \newphysicsquantity{linearmassdensity}{\reciprocal\m\usk\kg}[\kg\per\m][\kg\per\m]
250 \newphysicsquantity{areamassdensity}{\m\reciprocalsquared\usk\kg}[\kg\per\m\squared]
251 [\kg\per\m\squared]
252 \verb| newphysicsquantity{volumemassdensity}{\{\mreciprocalcubed\usk\kg\}[\kg\per\mrec]} 
253 [\kg\per\m\cubed]
254 \newphysicsquantity{youngsmodulus}{\reciprocal\m\usk\kg\usk\s\reciprocalsquared}
255 [\N\per\m\squared] [\Pa]
256 \newphysicsquantity{work}{\m\squared\usk\kg\usk\s\reciprocalsquared}[\J][\N\usk\m]
257 \newphysicsquantity{energy}{\m\squared\usk\kg\usk\s\reciprocalsquared}[\J][\N\usk\m]
258 \newphysicsquantity{power}{\m\squared\usk\kg\usk\s\reciprocalcubed}[\W][\J\per\s]
259 \newphysicsquantity{angularvelocity}{\rad\usk\reciprocal\s}[\rad\per\s] [\rad\per\s]
260 \newphysicsquantity{angularacceleration}{\rad\usk\s\reciprocalsquared}[\rad\per\s\squared]
261 [\rad\per\s\squared]
262 \newphysicsquantity{angularmomentum}{\m\squared\usk\kg\usk\reciprocal\s}[\J\usk\s]
263 [\kg\usk\m\squared\per\s]
264 \newphysicsquantity{momentofinertia}{\m\squared\usk\kg}[\J\usk\s\squared][\kg\usk\m\squared]
265 \newphysicsquantity{torque}{\m\squared\usk\kg\usk\s\reciprocalsquared}[\J\per\rad][\N\usk\m]
266 \newphysicsquantity{entropy}{\m\squared\usk\s\reciprocalsquared\usk\reciprocal\K}
267 [\J\per\K] [\J\per\K]
268 \newphysicsquantity{wavelength}\{\mbox{m}\ [\mbox{m}\ [\mbox{m}\ ]\mbox{m}\ ]
269 \newphysicsquantity{wavenumber}{\reciprocal\m}[\per\m][\per\m]
270 \newphysicsquantity{frequency}{\reciprocal\s}[\hertz][\hertz]
271 \newphysicsquantity{angularfrequency}{\rad\usk\reciprocal\s}[\rad\per\s][\rad\per\s]
272 \newphysicsquantity{charge}{\A\usk\s}[\C][\C]
273 \newphysicsquantity{permittivity}
274 {\tt \mreciprocalcubed\usk\reciprocal\kg\usk\sreciprocalquarted\usk\A\squared} \\
275 [\F\per\m] [\C\squared\per\N\usk\m\squared]
```

- 276 \newphysicsquantity{permeability}
- 277 {\m\usk\kg\usk\s\reciprocalsquared\usk\A\reciprocalsquared} [\henry\per\m] [\T\usk\m\per\A]
- 278 \newphysicsquantity{electricfield}{\m\usk\kg\usk\s\reciprocalcubed\usk\reciprocal\A}
- 279 [$V\neq m$] [$N\neq C$]
- $280 \ensuremath{\mbox{\mbox{$\mbox{}\mbox{$\mbox{}\mbox{$\mbox{}\box{$\mbox{}$
- 281 \newphysicsquantity{electricflux}{\m\cubed\usk\kg\usk\s\reciprocalcubed\usk\reciprocal\A}
- 282 [\V\usk\m] [\N\usk\m\squared\per\C]
- 283 \newphysicsquantity{magneticfield}{\kg\usk\s\reciprocalsquared\usk\reciprocal\A}[\T]
- 284 [\N\per\C\usk(\m\per\s)] % also \Wb\per\m\squared
- 285 \newphysicsquantity{magneticflux}
- $286 \ {\tt \n\squared\usk\kg\usk\s\reciprocalsquared\usk\reciprocal\A} \ [\volt\usk\s]$
- 287 [\T\usk\m\squared] % also \Wb and \J\per\A
- 288 \newphysicsquantity{cmagneticfield}{\m\usk\kg\usk\s\reciprocalcubed\usk\reciprocal\A}
- 289 [\V\per\m] [\N\per\C]
- 290 \newphysicsquantity{linearchargedensity}{\reciprocal\m\usk\s\usk\A}[\C\per\m][\C\per\m]
- $291 \ \texttt{\newphysicsquantity} \{ a reachargedensity \} \{ \texttt{\newphysicsquantity} \} \} \\$
- 292 [\C\per\square\m] [\C\per\square\m]
- 293 \newphysicsquantity{volumechargedensity}{\reciprocalcubic\m\usk\s\usk\A}
- 294 [\C\per\cubic\m] [\C\per\cubic\m]
- 295 \newphysicsquantity{mobility}
- 296 {\m\squared\usk\kg\usk\s\reciprocalquarted\usk\reciprocal\A}[\m\squared\per\volt\usk\s]
- 297 [($\mbox{\mbox{$\mathbb{N}$}}$)\per($\mbox{\mbox{$\mathbb{N}$}}$)]
- 298 \newphysicsquantity{numberdensity}{\reciprocalcubic\m][\per\cubic\m][\per\cubic\m]
- 299 \newphysicsquantity{polarizability}{\reciprocal\kg\usk\s\quarted\usk\square\A}
- 300 [\C\usk\square\m\per\V] [\C\usk\m\per(\N\per\C)]
- 301 \newphysicsquantity{electricpotential}
- 302 {\square\m\usk\kg\usk\reciprocalcubic\s\usk\reciprocal\A} [\J\per\C] [\V]
- 303 \newphysicsquantity{emf}{\square\m\usk\kg\usk\reciprocalcubic\s\usk\reciprocal\A}
- 304 [\J\per\C][\V]
- 305 \newphysicsquantity{dielectricconstant}{}[][]
- 306 \newphysicsquantity{indexofrefraction}{}[][]
- 307 \newphysicsquantity{relativepermittivity}{}[][]
- 308 \newphysicsquantity{relativepermeability}{}[][]
- 309 \newphysicsquantity{energydensity}{\m\reciprocaled\usk\kg\usk\reciprocalsquare\s}
- 310 [\J\per\cubic\m] [\J\per\cubic\m]
- 311 \newphysicsquantity{energyflux}{\kg\usk\s\reciprocalcubed}
- 312 [\W\per\m\squared] [\W\per\m\squared]
- 313 \newphysicsquantity{electroncurrent}{\reciprocal\s}
- 314 [\ensuremath{\mathrm{e}}\per\s] [\ensuremath{\mathrm{e}}\per\s]
- 315 \newphysicsquantity{conventionalcurrent}{\A}[\C\per\s][\A]
- 317 \newphysicsquantity{currentdensity}{\reciprocalsquare\m\usk\A}[\C\usk\s\per\square\m]
- 318 [\A\per\square\m]
- 319 \newphysicsquantity{capacitance}
- 320 {\reciprocalsquare\m\usk\reciprocal\kg\usk\quartic\s\usk\square\A}[\F][\C\per\V]
- 321 % also \C\squared\per\N\usk\m, \s\per\ohm
- 322 \newphysicsquantity{inductance}
- $324 \$ [\volt\usk\s\per\A] % also \square\m\usk\kg\per\C\squared, \Wb\per\A
- $325 \verb| newphysicsquantity{conductivity}|$

```
326 {\reciprocalcubic\m\usk\reciprocal\kg\usk\cubic\s\usk\square\A} [\siemens\per\m]
327 [(\A\per\square\m)\per(\V\per\m)]
328 \newphysicsquantity{resistivity}
329 {\cubic\m\usk\reciprocalcubic\s\usk\reciprocalsquare\A} [\ohm\usk\m]
330 [(\V\per\m)\per(\A\per\square\m)]
331 \newphysicsquantity{resistance}
332 {\square\m\usk\kg\usk\reciprocalcubic\s\usk\reciprocalsquare\A} [\V\per\A] [\ohm]
333 \newphysicsquantity{conductance}
334 {\reciprocalsquare\m\usk\reciprocal\kg\usk\cubic\s\usk\square\A} [\A\per\V] [\siemens]
335 \newphysicsquantity{magneticcharge}{\m\usk\A}[\m\usk\A][\m\usk\A]
336 \newcommand{\lv}{\ensuremath{\left\langle}}
337 \newcommand{\rv}{\ensuremath{\right\rangle}}
338 \newcommand{\symvect}{\mivector}
339 \newcommand{\ncompsvect}{\mivector}
340 \ExplSyntaxOn % Written in LaTeX3
341 \NewDocumentCommand{\magvectncomps}{ m O{} }
342
     ₹%
       \sum_of_squares:nn { #1 }{ #2 }
343
    }%
344
345 \cs_new:Npn \sum_of_squares:nn #1 #2
346
347
       \tl_if_empty:nTF { #2 }
        {%
348
           \clist_set:Nn \l_tmpa_clist { #1 }
349
          \ensuremath{%
350
            \sqrt{(\clist_use:Nnnn \l_tmpa_clist { )^2+( } { )^2+( } { )^2+( } )^2 }
351
352
          }%
        }%
353
         {%
354
           \clist_set:Nn \l_tmpa_clist { #1 }
355
          \ensuremath{%
356
            357
            {\;{ #2 })^2+(} \;{ #2 })^2}
358
          }%
359
360
        }%
361
    }%
362 \ExplSyntaxOff
363 %
364 \newcommand{\zerovect}{\vect{0}}
365 \newcommand{\ncompszerovect}{\mivector{0,0,0}}
366 \ifthenelse{\boolean{@optitalicvectors}}
     {\newcommand{\vect}[1]{\ensuremath{\vec{#1}}}}
     369 \ifthenelse{\boolean{@optdoubleabsbars}}
     {\magnet}[1]{\magnet}{\magnet}{\magnet}{\magnet}{\magnet}
     {\newcommand{\magvect}[1]{\ensuremath{\abs{\vect{#1}}}}}
372 \newcommand{\dmagvect}[1]{\ensuremath{\dx{\magvect{#1}}}}
373 \newcommand{\Dmagvect}[1]{\ensuremath{\Delta\!\magvect{#1}}}
374 \ifthenelse{\boolean{@optitalicvectors}}
     {\ensuremath{\ensuremath{\#1}}}
```

```
376
     {\newcommand{\dirvect}[1]{\ensuremath{\widehat{\mathrm{#1}}}}}
377 \ifthenelse{\boolean{@optitalicvectors}}
     {\newcommand{\compvect}[2]{\newcommand{\cmpvect}[2]}}
378
     379
   \newcommand{\scompsvect}[1]{\ensuremath{\lv}
380
     \compvect{#1}{x},
381
382
     \compvect{#1}{y},
383
     \compvect{#1}{z}\rv}
384 \newcommand{\magvectscomps}[1]{\ensuremath{\sqrt{}}
385
     \mbox{msup{\compvect{#1}{x}}{2}+}
     \mbox{msup}{\compvect{#1}{y}}{2}+
386
     \mbox{msup{\compvect{#1}{z}}{2}}}
387
388 \newcommand{\dvect}[1]{\ensuremath{\mathrm{d}\vect{#1}}}
389 \newcommand{\Dvect}[1]{\ensuremath{\Delta\vect{#1}}}
390 \newcommand{\dirdvect}[1]{\ensuremath{\widehat{\dvect{#1}}}}
391 \newcommand{\dirDvect}[1]{\ensuremath{\widehat{\Dvect{#1}}}}
392 \newcommand{\ddirvect}[1]{\ensuremath{\mathrm{d}\dirvect{E}}}}
393 \newcommand{\Ddirvect}[1]{\ensuremath{\Delta\dirvect{E}}}
394 \ifthenelse{\boolean{@optdoubleabsbars}}
     {\newcommand{\magdvect}[1]{\ensuremath{\magof{\dvect{#1}}}}
395
396
      \newcommand{\magDvect}[1]{\ensuremath{\magof{\Dvect{#1}}}}}
397
     {\newcommand{\magdvect}[1]{\ensuremath{\abs{\dvect{#1}}}}
398
      \newcommand{\magDvect}[1]{\ensuremath{\abs{\Dvect{#1}}}}}
399 \newcommand{\compdvect}[2]{\ensuremath{\mathrm{d}\compvect{#1}{#2}}}
400 \newcommand{\compDvect}[2]{\ensuremath{\Delta\compvect{#1}{#2}}}
401 \newcommand{\scompsdvect}[1]{\ensuremath{\lv}
     \compdvect{#1}{x},
402
     \compdvect{#1}{y},
403
     \compdvect{#1}{z}\rv}}
404
   \newcommand{\scompsDvect}[1]{\ensuremath{\lv
405
     \compDvect{#1}{x},
406
     \compDvect{#1}{y},
407
     \compDvect{#1}{z}\rv}}
408
409 \newcommand{\dervect}[2]{\ensuremath{\frac{\dvect{#1}}}{\mathrm{d}{#2}}}}
410 \newcommand{\Dervect}[2]{\ensuremath{\frac{\Dvect{#1}}{\Delta{#2}}}}
411 \newcommand{\compdervect}[3]{\ensuremath{\dbyd{\compvect{#1}{#2}}{#3}}}
412 \newcommand{\compDervect}[3]{\ensuremath{\DbyD{\compvect{#1}{#2}}{#3}}}
413 \newcommand{\scompsdervect}[2]{\ensuremath{\lv}}
     \compdervect{\#1}{x}{\#2},
414
415
     \compdervect{#1}{y}{#2},
     \compdervect{#1}{z}{#2}\rv}
417 \newcommand{\scompsDervect}[2]{\ensuremath{\lv}
     \compDervect{\#1}{x}{\#2},
418
     \compDervect{#1}{y}{#2},
419
     \compDervect{#1}{z}{#2}\rv}
420
    ifthenelse{\boolean{@optdoubleabsbars}}
421
422
     {\newcommand{\magdervect}[2]{\ensuremath{\magof{\dervect{#1}{#2}}}}
423
      \newcommand{\magDervect}[2]{\ensuremath{\magof{\Dervect{#1}{#2}}}}}
424
     {\newcommand{\magdervect}[2]{\ensuremath{\abs{\dervect{#1}{#2}}}}
      \newcommand{\magDervect}[2]{\ensuremath{\abs{\Dervect{#1}{#2}}}}}
425
```

```
426 \newcommand{\dermagvect}[2]{\ensuremath{\dbyd{\magvect{#1}}{#2}}}
427 \newcommand{\Dermagvect}[2]{\ensuremath{\DbyD{\magvect{#1}}{#2}}}
428 \newcommand{\scompspos}{\mivector{x,y,z}}
429 \newcommand{\comppos}[1]{\ensuremath{{#1}}}
430 \mbox{ \mbox{\mbox{mathrm}$\{d\}y,\mbox{\mbox{mathrm}$\{d\}z\}}}
431 \newcommand{\scompsDpos}{\mivector{\Delta x,\Delta y,\Delta z}}
432 \newcommand{\compdpos}[1]{\ensuremath{\mathrm{d}{#1}}}
433 \newcommand{\compDpos}[1]{\ensuremath{\Delta{#1}}}
434 \newcommand{\scompsderpos}[1]{\ensuremath{\lv
435
                 \frac{d}{x}{\mathcal{d}^{\#1}},\frac{d}{y}{\mathcal{d}^{\#1}},
                       \frac{d}{z}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{d}}{\mathbf{
436
437 \newcommand{\scompsDerpos}[1]{\ensuremath{\lv}
                 \frac{\Delta x}{\Delta{#1}},\frac{\Delta y}{\Delta{#1}},
438
439
                       \frac{\Delta z}{\Delta{#1}}\rv}}
440 \newcommand{\compderpos}[2]{\ensuremath{\frac{\mathbb{41}}{\mathbb{41}}}}
441 \newcommand{\compDerpos}[2]{\ensuremath{\frac{\Delta{#1}}{\Delta{#2}}}}
442 \mbox{\westsub}[2]{\ensuremath{\ssub{\vect{#1}}{\#2}}}
443 \ifthenelse{\boolean{@optitalicvectors}}
                 {\mbox{\new command \compvectsub} [3] {\mbox{\new command \compvectsub}}}}
444
                 {\mbox{\mbox{\mbox{$\sim$}}}}{\mbox{\mbox{\mbox{$\sim$}}}}
445
446 \newcommand{\scompsvectsub}[2]{\ensuremath{\lv}
                 \compvectsub{#1}{x}{#2},
448
                 \compvectsub{#1}{v}{#2}.
                 \compvectsub{#1}{z}{#2}\rv}
449
450 \ifthenelse{\boolean{@optdoubleabsbars}}
                 {\mode 
451
                 {\newcommand{\magvectsub}[2]{\ensuremath{\abs{\vectsub{#1}{#2}}}}}
452
          \newcommand{\magvectsubscomps}[2]{\ensuremath{\sqrt{}}
453
                       \mbox{msup}{\compvectsub}{\#1}{x}{\#2}}{2}+
454
                       \mbox{msup}{\compvectsub}{\#1}{y}{\#2}}{2}+
455
                       \mbox{msup{\compvectsub{#1}{z}{#2}}{2}}}
456
457 \ifthenelse{\boolean{@optitalicvectors}}
                 {\newcommand{\dirvectsub}[2]{\ensuremath{\ssub{\widehat{#1}}{#2}}}}
458
                 {\newcommand{\dirvectsub}[2]{\ensuremath{\ssub{\widehat{\mathrm{#1}}}{#2}}}}
460 \newcommand{\dvectsub}[2]{\ensuremath{\mathrm{d}\vectsub{#1}{#2}}}
461 \newcommand{\Dvectsub}[2]{\ensuremath{\Delta\vectsub{#1}{#2}}}
462 \newcommand{\compdvectsub}[3]{\ensuremath{\mathrm{d}\compvectsub{#1}{#2}{#3}}}
463 \newcommand{\compDvectsub}[3]{\ensuremath{\Delta\compvectsub{#1}{#2}{#3}}}
464 \newcommand{\scompsdvectsub}[2]{\ensuremath{\lv}}
                 \compdvectsub{#1}{x}{#2},
465
                 \compdvectsub{#1}{y}{#2},
466
                 \compdvectsub{#1}{z}{#2}\rv}
467
          \newcommand{\scompsDvectsub}[2]{\ensuremath{\lv
468
                 \compDvectsub{#1}{x}{#2},
469
                 \compDvectsub{#1}{y}{#2},
470
                 \compDvectsub{#1}{z}{#2}\rv}
471
472 \mbox{\dermagvectsub} [3] {\ensuremath{\dbyd{\mathbb{4}1}{\#2}}{\#3}}}
473 \newcommand{\Dermagvectsub}[3]{\ensuremath{\DbyD{\magvectsub{#1}{#2}}{#3}}}
474 \newcommand{\dervectsub}[3]{\ensuremath{\dbyd{\vectsub{#1}{#2}}{#3}}}
475 \newcommand{\Dervectsub}[3]{\ensuremath{\DbyD{\vectsub{#1}{#2}}{#3}}}
```

```
476 \ifthenelse{\boolean{@optdoubleabsbars}}
477
          {\newcommand{\magdervectsub}[3]{\ensuremath{\magof{\dervectsub{#1}{#2}{#3}}}}
            \newcommand{\magDervectsub}[3]{\ensuremath{\magof{\Dervectsub{#1}{#3}}}}}
478
         {\model} [3] {\model} [4] {\m
479
           \newcommand{\magDervectsub}[3]{\ensuremath{\abs{\Dervectsub{#1}{#2}{#3}}}}}
480
481 \newcommand{\compdervectsub}[4]{\ensuremath{\dbyd{\compvectsub{#1}{#2}{#3}}{#4}}}
      \newcommand{\compDervectsub}[4]{\ensuremath{\DbyD{\compvectsub{#1}{#2}{#3}}{#4}}}
      \newcommand{\scompsdervectsub}[3]{\ensuremath{\lv}
484
         \compdervectsub{#1}{x}{#2}{#3},
485
          \compdervectsub{\#1}{v}{\#2}{\#3},
         \compdervectsub{#1}{z}{#2}{#3}\rv}
486
487 \newcommand{\scompsDervectsub}[3]{\ensuremath{\lv
         \compDervectsub{#1}{x}{#2}{#3},
488
489
         \compDervectsub{#1}{y}{#2}{#3},
         \compDervectsub{#1}{z}{#2}{#3}\rv}
491 \newcommand{\comppossub}[2]{\ensuremath{\ssub{#1}{#2}}}
492 \newcommand{\scompspossub}[1]{\ensuremath{\lv}
         \comppossub{x}{\#1},
493
         \comppossub{y}{#1},
494
         \comppossub{z}{\#1}\rv}
495
496 \newcommand{\compdpossub}[2]{\ensuremath{\mathrm{d}\comppossub{#1}{#2}}}
497 \newcommand{\compDpossub}[2]{\ensuremath{\Delta\comppossub{#1}{#2}}}
      \newcommand{\scompsdpossub}[1]{\ensuremath{\lv}
          \compdpossub{x}{\#1},
499
         \compdpossub{y}{#1},
500
         \compdpossub{z}{#1}\rv}}
501
502 \newcommand{\scompsDpossub}[1]{\ensuremath{\lv
         \compDpossub{x}{\#1},
503
         \compDpossub{y}{#1},
504
         \compDpossub{z}{#1}\rv}}
505
506 \mbox{ \newcommand{\compderpossub}[3]{\ensuremath{\dbyd{\comppossub{#1}{#2}}}}
      \newcommand{\compDerpossub}[3]{\ensuremath{\DbyD{\comppossub{#1}{#2}}{#3}}}
      \newcommand{\scompsderpossub}[2]{\ensuremath{\lv}
         \compderpossub{x}{\#1}{\#2},
509
510
         \compderpossub{y}{#1}{#2},
          \compderpossub{z}{#1}{#2}\rv}}
511
512 \newcommand{\scompsDerpossub}[2]{\ensuremath{\lv
         \compDerpossub{x}{\#1}{\#2},
513
         \compDerpossub{y}{#1}{#2},
514
         \compDerpossub{z}{#1}{#2}\rv}
516 \ensuremath{\vectsub\{r\}\{\#1\}\}}
517 \newcommand{\relvel}[1]{\ensuremath{\vectsub{v}{#1}}}
518 \newcommand{\relmom}[1]{\ensuremath{\vectsub{p}{#1}}}
519 \mbox{ } mand{\relfor}[1]{\ensuremath{\vectsub{F}{\#1}}}
520 \newcommand{\vectdotvect}[2]{\ensuremath{{\#1}\bullet{\#2}}}
521 \newcommand{\vectdotsvect}[2]{\ensuremath{\scompsvect{#1}\bullet\scompsvect{#2}}}
522 \newcommand{\vectdotevect}[2]{\ensuremath{
523
         \compvect{#1}{x}\compvect{#2}{x}+
524
          \compvect{#1}{y}\compvect{#2}{y}+
         \compvect{#1}{z}\compvect{#2}{z}}
525
```

```
526 \newcommand{\vectdotspos}[1]{\ensuremath{\scompsvect{#1}\bullet\scompspos}}
527 \newcommand{\vectdotepos}[1]{\ensuremath{
     \compvect{#1}{x}\comppos{x}+
528
     \compvect{#1}{y}\comppos{y}+
529
     \compvect{#1}{z}\comppos{z}}}
530
531 \newcommand{\vectdotsdvect}[2]{\ensuremath{\scompsvect{#1}\bullet\scompsdvect{#2}}}
   \newcommand{\vectdotsDvect}[2]{\ensuremath{\scompsvect{#1}\bullet\scompsDvect{#2}}}}
   \newcommand{\vectdotedvect}[2]{\ensuremath{
534
     \compvect{#1}{x}\compdvect{#2}{x}+
535
     \compvect{#1}{v}\compdvect{#2}{v}+
     \compvect{#1}{z}\compdvect{#2}{z}}
536
537 \newcommand{\vectdoteDvect}[2]{\ensuremath{
     \compvect{#1}{x}\compDvect{#2}{x}+
538
539
     \compvect{#1}{y}\compDvect{#2}{y}+
     \compvect{#1}{z}\compDvect{#2}{z}}
541 \newcommand{\vectdotsdpos}[1]{\ensuremath{\scompsvect{#1}\bullet\scompsdpos}}
542 \newcommand{\vectdotsDpos}[1]{\ensuremath{\scompsvect{#1}\bullet\scompsDpos}}
543 \mbox{ }\mbox{newcommand{\vectdotedpos}[1]{\columnwidth{}}}
     \compvect{#1}{x}\compdpos{x}+
544
     \compvect{#1}{y}\compdpos{y}+
545
     \compvect{#1}{z}\compdpos{z}}}
546
547 \newcommand{\vectdoteDpos}[1]{\ensuremath{
548
     \compvect{#1}{x}\compDpos{x}+
     \compvect{#1}{y}\compDpos{y}+
549
     \compvect{#1}{z}\compDpos{z}}}
550
   \newcommand{\vectsubdotsvectsub}[4]{\ensuremath{}
551
     \scompsvectsub{#1}{#2}\bullet\scompsvectsub{#3}{#4}}}
552
    newcommand{\vectsubdotevectsub}[4]{\ensuremath{
553
     \compvectsub{#1}{x}{#2}\compvectsub{#3}{x}{#4}+
554
     \compvectsub{#1}{v}{\#2}\compvectsub{#3}{v}{\#4}+
555
     \verb|\compvectsub{#1}{z}{#2}\\| compvectsub{#3}{z}{#4}}|
556
   \newcommand{\vectsubdotsdvectsub}[4]{\ensuremath{%
557
     \scompsvectsub{#1}{#2}\bullet\scompsdvectsub{#3}{#4}}}
   \newcommand{\vectsubdotsDvectsub}[4]{\ensuremath{%
559
     \scompsvectsub{#1}{#2}\bullet\scompsDvectsub{#3}{#4}}}
560
561
   \newcommand{\vectsubdotedvectsub}[4]{\ensuremath{}
     \compvectsub{#1}{x}{#2}\compdvectsub{#3}{x}{#4}+
562
     \compvectsub{#1}{y}{#2}\compdvectsub{#3}{y}{#4}+
563
     \compvectsub{#1}{z}{#2}\compdvectsub{#3}{z}{#4}}
564
    newcommand{\rectsubdoteDrectsub}[4]{\ensuremath{}
     \compvectsub{#1}{x}{#2}\compDvectsub{#3}{x}{#4}+
566
     \compvectsub{#1}{y}{#2}\compDvectsub{#3}{y}{#4}+
567
     \compvectsub{#1}{z}{#2}\compDvectsub{#3}{z}{#4}}
568
    newcommand{\vectsubdotsdvect}[3]{\ensuremath{
569
     \scompsvectsub{#1}{#2}\bullet\scompsdvect{#3}}}
570
    newcommand{\vectsubdotsDvect}[3]{\ensuremath{
571
     \scompsvectsub{#1}{#2}\bullet\scompsDvect{#3}}}
573
   \newcommand{\vectsubdotedvect}[3]{\ensuremath{}
574
     \compvectsub{#1}{x}{#2}\compdvect{x}{#3}+
     \compvectsub{#1}{y}{#2}\compdvect{y}{#3}+
575
```

```
\compvectsub{#1}{z}{#2}\compdvect{z}{#3}}
576
577
   \newcommand{\vectsubdoteDvect}[3]{\ensuremath{}
     \compvectsub{#1}{x}{#2}\compDvect{x}{#3}+
578
     \compvectsub{#1}{y}{#2}\compDvect{y}{#3}+
579
     \verb|\compvectsub{#1}{z}{#2}\\| compDvect{z}{#3}}|
580
581
   \newcommand{\vectsubdotsdpos}[2]{\ensuremath{}
     \scompsvectsub{#1}{#2}\bullet\scompsdpos}}
582
583
   \newcommand{\vectsubdotsDpos}[2]{\ensuremath{}
584
     \scompsvectsub{#1}{#2}\bullet\scompsDpos}}
585
   \newcommand{\vectsubdotedpos}[2]{\ensuremath{
     \compvectsub{#1}{x}{#2}\compdpos{x}+
586
     \compvectsub{#1}{y}{#2}\compdpos{y}+
587
     \compvectsub{#1}{z}{#2}\compdpos{z}}
588
589
   \newcommand{\vectsubdoteDpos}[2]{\ensuremath{
     \compvectsub{#1}{x}{#2}\compDpos{x}+
590
     \compvectsub{#1}{y}{#2}\compDpos{y}+
591
     \compvectsub{#1}{z}{#2}\compDpos{z}}}
592
   \newcommand{\dervectdotsvect}[3]{\ensuremath{
593
     \scompsdervect{#1}{#2}\bullet\scompsvect{#3}}}
594
    newcommand{\Dervectdotsvect}[3]{\ensuremath{
595
     \scompsDervect{#1}{#2}\bullet\scompsvect{#3}}}
597
   \newcommand{\dervectdotevect}[3]{\ensuremath{
     \compdervect{#1}{x}{#2}\compvect{x}{#3}+
598
     \compdervect{#1}{y}{\#2}\setminus compvect{y}{\#3}+
599
     \compdervect{#1}{z}{\#2}\setminus compvect{z}{\#3}}
600
601 \newcommand{\Dervectdotevect}[3]{\ensuremath{
     \compDervect{#1}{x}{\#2}\setminus compvect{x}{\#3}+
602
     \compDervect{#1}{y}{#2}\setminus compvect{y}{#3}+
603
     \compDervect{#1}{z}{#2}\compvect{z}{#3}}
604
   \newcommand{\vectdotsdervect}[3]{\ensuremath{}
605
     \scompsvect{#1}\bullet\scompsdervect{#2}{#3}}}
606
   \newcommand{\vectdotsDervect}[3]{\ensuremath{}
607
     \scompsvect{#1}\bullet\scompsDervect{#2}{#3}}}
608
   \newcommand{\vectdotedervect}[3]{\ensuremath{
609
610
     \compvect{#1}{x}\compdervect{#2}{x}{#3}+
     \compvect{#1}{v}\compdervect{#2}{v}{#3}+
611
     \compvect{#1}{z}\compdervect{#2}{z}{#3}}
612
613 \newcommand{\vectdoteDervect}[3]{\ensuremath{
     \compvect{#1}{x}\compDervect{#2}{x}{#3}+
614
     \compvect{#1}{y}\compDervect{#2}{y}{#3}+
615
     \compvect{#1}{z}\compDervect{#2}{z}{#3}}
616
   \newcommand{\dervectdotspos}[2]{\ensuremath{
     \scompsdervect{#1}{#2}\bullet\scompspos}}
618
   \newcommand{\Dervectdotspos}[2]{\ensuremath{}
619
     \scompsDervect{#1}{#2}\bullet\scompspos}}
620
621 \newcommand{\dervectdotepos}[2]{\ensuremath{
622
     \compdervect{#1}{x}{#2}\comppos{x}+
623
     \compdervect{#1}{y}{#2}\comppos{y}+
     \compdervect{#1}{z}{#2}\comppos{z}}}
625 \newcommand{\Dervectdotepos}[2]{\ensuremath{
```

```
626
             \compDervect{#1}{x}{#2}\comppos{x}+
627
             \compDervect{#1}{y}{#2}\comppos{y}+
628
             \compDervect{#1}{z}{#2}\comppos{z}}
        \newcommand{\dervectdotsdvect}[3]{\ensuremath{
629
             \scompsdervect{#1}{#2}\bullet\scompsdvect{#3}}}
630
631
        \newcommand{\DervectdotsDvect}[3]{\ensuremath{
632
              \scompsDervect{#1}{#2}\bullet\scompsDvect{#3}}}
633
        \newcommand{\dervectdotedvect}[3]{\ensuremath{
634
              \compdervect{#1}{x}{#2}\compdvect{#3}{x}+
635
              \compdervect{#1}{v}{\#2}\setminus compdvect{\#3}{v}+
              \compdervect{#1}{z}{#2}\compdvect{#3}{z}}
636
637 \newcommand{\DervectdoteDvect}[3]{\ensuremath{
             \compDervect{#1}{x}{#2}\compDvect{#3}{x}+
638
639
             \compDervect{#1}{y}{#2}\compDvect{#3}{y}+
             \compDervect{#1}{z}{\#2}\setminus compDvect{\#3}{z}}
640
641 \newcommand{\dervectdotsdpos}[2]{\ensuremath{
              \scompsdervect{#1}{#2}\bullet\scompsdpos}}
642
643 \newcommand{\DervectdotsDpos}[2]{\ensuremath{
              \scompsDervect{#1}{#2}\bullet\scompsDpos}}
644
645 \newcommand{\dervectdotedpos}[2]{\ensuremath{
             \compdervect{#1}{x}{#2}\compdpos{x}+
646
647
             \compdervect{#1}{y}{#2}\compdpos{y}+
648
              \compdervect{#1}{z}{#2}\compdpos{z}}}
649 \newcommand{\DervectdoteDpos}[2]{\ensuremath{
             \compDervect{#1}{x}{#2}\compDpos{x}+
650
             \compDervect{#1}{y}{#2}\compDpos{y}+
651
             \compDervect{#1}{z}{#2}\compDpos{z}}}
652
653 \newcommand{\vectcrossvect}[2]{\ensuremath{{#1}\times{#2}}}
654 \newcommand{\ltriplecross}[3]{\ensuremath{({#1}\times{#2})\times{#3}}}
        \newcommand{\rtriplecross}[3]{\ensuremath{{\#1}\times({\#2}\times{\#3})}}
        \newcommand{\ltriplescalar}[3]{\ensuremath{{#1}\times{#2}\bullet{#3}}}
        \newcommand{\rtriplescalar}[3]{\ensuremath{{#1}\bullet{#2}\times{#3}}}
658 \mode {\mode \mode \mode
659 \newcommand{\eone}{\ensuremath{\msub{\mathbf{e}}}{1}}}
660 \newcommand{\etwo}{\ensuremath{\msub{\mathbf{e}}}{2}}}
661 \newcommand{\ethree}{\ensuremath{\msub{\mathbf{e}}}{3}}}
662 \mode {\mode \mode \mode
663 \mbox{\ensuremath{\msub{\mathbb{e}}}{#1}}}
664 \newcommand{\e}{\ek}
665 \newcommand{\uezero}{\ensuremath{\msub{\widehat{\mathbf{e}}}}{0}}}
666 \newcommand{\ueone}{\ensuremath{\msub{\widehat{\mathbf{e}}}{1}}}
667 \newcommand{\uetwo}{\ensuremath{\msub{\widehat{\mathbf{e}}}}{2}}}
668 \mbox{ \newcommand{\uethree}{\newcommand{\uethree}}}{3}}
669 \end{\uefour} {\nsub{\widehat{\mathbb{e}}}} {4}} \}
670 \newcommand{\uek}[1]{\ensuremath{\msub{\widehat{\mathbf{e}}}}{#1}}}
671 \newcommand{\ue}{\uek}
672 \newcommand{\ezerozero}{\ek{00}}
673 \newcommand{\ezeroone}{\ek{01}}
674 \newcommand{\ezerotwo}{\ek{02}}
675 \newcommand{\ezerothree}{\ek{03}}
```

```
676 \newcommand{\ezerofour}{\ek{04}}
677 \newcommand{\eoneone}{\ek{11}}
678 \newcommand{\eonetwo}{\ek{12}}
679 \newcommand{\eonethree}{\ek{13}}
680 \newcommand{\eonefour}{\ek{14}}
681 \newcommand{\etwoone}{\ek{21}}
682 \newcommand{\etwotwo}{\ek{22}}
683 \newcommand{\etwothree}{\ek{23}}
684 \newcommand{\etwofour}{\ek{24}}
685 \newcommand{\ethreeone}{\ek{31}}
686 \newcommand{\ethreetwo}{\ek{32}}
687 \newcommand{\ethreethree}{\ek{33}}
688 \newcommand{\ethreefour}{\ek{34}}
689 \newcommand{\efourone}{\ek{41}}
690 \newcommand{\efourtwo}{\ek{42}}
691 \newcommand{\efourthree}{\ek{43}}
692 \newcommand{\efourfour}{\ek{44}}
693 \newcommand{\euzero}{\ensuremath{\msup{\mathbf{e}}}{0}}}
694 \mode {\mode } 
695 \newcommand{\eutwo}{\ensuremath{\msup{\mathbf{e}}}{2}}}
696 \newcommand{\euthree}{\ensuremath{\msup{\mathbf{e}}}{3}}}
697 \newcommand{\eufour}{\ensuremath{\msup{\mathbf{e}}}{4}}}
698 \newcommand{\euk}[1]{\ensuremath{\msup{\mathbf{e}}}{#1}}}
699 \newcommand{\eu}{\euk}
700 \newcommand{\euzerozero}{\euk{00}}
701 \newcommand{\euzeroone}{\euk{01}}
702 \newcommand{\euzerotwo}{\euk{02}}
703 \newcommand{\euzerothree}{\euk{03}}
704 \newcommand{\euzerofour}{\euk{04}}
705 \newcommand{\euoneone}{\euk{11}}
706 \newcommand{\euonetwo}{\euk{12}}
707 \newcommand{\euonethree}{\euk{13}}
708 \newcommand{\euonefour}{\euk{14}}
709 \newcommand{\eutwoone}{\euk{21}}
710 \newcommand{\eutwotwo}{\euk{22}}
711 \newcommand{\eutwothree}{\euk{23}}
712 \newcommand{\eutwofour}{\euk{24}}
713 \newcommand{\euthreeone}{\euk{31}}
714 \newcommand{\euthreetwo}{\euk{32}}
715 \newcommand{\euthreethree}{\euk{33}}
716 \newcommand{\euthreefour}{\euk{34}}
717 \newcommand{\eufourone}{\euk{41}}
718 \newcommand{\eufourtwo}{\euk{42}}
719 \newcommand{\eufourthree}{\euk{43}}
720 \newcommand{\eufourfour}{\euk{44}}
721 \newcommand{\gzero}{\ensuremath{\msub{\mathbf{\gamma}}{0}}}
722 \newcommand{\gone}{\ensuremath{\msub{\mathbf{\gamma}}{1}}}
723 \mbox{\mbox{\mbox{$\mbox{\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{}\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{}\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{$\mbox{
724 \newcommand{\gthree}{\ensuremath{\msub{\mathbf{\gamma}}{3}}}
725 \newcommand{\gfour}{\ensuremath{\msub{\mathbf{\gamma}}{4}}}
```

```
726 \newcommand{\gk}[1]{\ensuremath{\msub{\mathbf{\gamma}}{#1}}}
727 \newcommand{\g}{\gk}
728 \newcommand{\gzerozero}{\gk{00}}
729 \newcommand{\gzeroone}{\gk{01}}
730 \newcommand{\gzerotwo}{\gk{02}}
731 \newcommand{\gzerothree}{\gk{03}}
732 \newcommand{\gzerofour}{\gk{04}}
733 \newcommand{\goneone}{\gk{11}}
734 \newcommand{\gonetwo}{\gk{12}}
735 \newcommand{\gonethree}{\gk{13}}
736 \newcommand{\gonefour}{\gk{14}}
737 \newcommand{\gtwoone}{\gk{21}}
738 \newcommand{\gtwotwo}{\gk{22}}
739 \newcommand{\gtwothree}{\gk{23}}
740 \newcommand{\gtwofour}{\gk{24}}
741 \newcommand{\gthreeone}{\gk{31}}
742 \newcommand{\gthreetwo}{\gk\{32\}}
743 \newcommand{\gthreethree}{\gk{33}}
744 \newcommand{\gthreefour}{\gk{34}}
745 \newcommand{\gfourone}{\gk{41}}
746 \newcommand{\gfourtwo}{\gk{42}}
747 \newcommand{\gfourthree}{\gk{43}}
748 \newcommand{\gfourfour}{\gk{44}}
749 \newcommand{\guzero}{\ensuremath{\msup{\mathbf{\gamma}}{0}}}
750 \newcommand{\guone}{\ensuremath{\msup{\mathbf{\gamma}}{1}}}
751 \newcommand{\gutwo}{\ensuremath{\msup{\mathbf{\gamma}}{2}}}
752 \newcommand{\guthree}{\ensuremath{\msup{\mathbf{\gamma}}{3}}}
753 \newcommand{\gufour}{\ensuremath{\msup{\mathbf{\gamma}}{4}}}
754 \newcommand{\guk}[1]{\ensuremath{\msup{\mathbf{\gamma}}{#1}}}
755 \newcommand{\gu}{\guk}
756 \newcommand{\guzerozero}{\guk{00}}
757 \newcommand{\guzeroone}{\guk{01}}
758 \newcommand{\guzerotwo}{\guk{02}}
759 \newcommand{\guzerothree}{\guk{03}}
760 \newcommand{\guzerofour}{\guk{04}}
761 \newcommand{\guoneone}{\guk{11}}
762 \newcommand{\guonetwo}{\guk{12}}
763 \newcommand{\guonethree}{\guk{13}}
764 \newcommand{\guonefour}{\guk{14}}
765 \newcommand{\gutwoone}{\guk{21}}
766 \newcommand{\gutwotwo}{\guk{22}}
767 \newcommand{\gutwothree}{\guk{23}}
768 \newcommand{\gutwofour}{\guk{24}}
769 \newcommand{\guthreeone}{\guk{31}}
770 \newcommand{\guthreetwo}{\guk{32}}
771 \newcommand{\guthreethree}{\guk{33}}
772 \newcommand{\guthreefour}{\guk{34}}
773 \newcommand{\gufourone}{\guk{41}}
774 \newcommand{\gufourtwo}{\guk{42}}
775 \newcommand{\gufourthree}{\guk{43}}
```

```
776 \newcommand{\gufourfour}{\guk{44}}
777 \ExplSyntaxOn % Vectors formated as in M\&I, written in LaTeX3
778 \NewDocumentCommand{\mivector}{ O{,} m o }%
   {%
779
      \mi_vector:nn { #1 } { #2 }
780
      \IfValueT{#3}{\;{#3}}
781
782 }%
783 \seq_new:N \l__mi_list_seq
784 \cs_new_protected:Npn \mi_vector:nn #1 #2
785 {%
     \ensuremath{%
786
       \seq_set_split:Nnn \l__mi_list_seq { , } { #2 }
787
       \int_compare:nF { \seq_count:N \l__mi_list_seq = 1 } { \left\langle }
788
789
       \seq_use:Nnnn \l__mi_list_seq { #1 } { #1 } { #1 }
       \int_compare:nF { \seq_count:N \l__mi_list_seq = 1 } { \right\rangle }
790
    }%
791
792 }%
793 \ExplSyntaxOff
794 \ExplSyntaxOn % Column and row vectors, written in LaTeX3
795 \seq_new:N \l_vector_arg_seq
796 \cs_new_protected:Npn \vector_main:nnnn #1 #2 #3 #4
797 {%
     \seq_set_split:Nnn \l__vector_arg_seq { #3 } { #4 }
798
     \begin{#1matrix}
799
       \seq_use:Nnnn \l__vector_arg_seq { #2 } { #2 } { #2 }
800
     \end{#1matrix}
801
802 }%
803 \NewDocumentCommand{\rowvector}{ O{,} m }
804
     \ensuremath{
805
     \vector_main:nnnn { p } { \,\, } { #1 } { #2 }
806
     }%
807
808 }%
809 \NewDocumentCommand{\colvector}{ O{,} m }
810 {%
     \ensuremath{
811
     \vector_main:nnnn { p } { \\ } { #1 } { #2 }
812
    }%
813
814 }%
815 \ExplSyntaxOff
816 \newcommandx{\scompscvect}[2][1,usedefault]{%
     \left\{ \left( \frac{\#1}{\$} \right) \right\}
817
818
       \colvector{\msub{#2}{1},\msub{#2}{2},\msub{#2}{3}}%
819
     }%
820
821
822
       \colvector{\msub{#2}{0},\msub{#2}{1},\msub{#2}{2},\msub{#2}{3}}
823
825 \newcommandx{\scompsrvect}[2][1,usedefault]{%
```

```
826
            \ifthenelse{\equal{#1}{}}%
827
                 \color{0.7} \color{0.7} {\color{0.7} {\col
828
            }%
829
            {%
830
                 831
           }%
832
833 }%
834 \neq 0
835 {\scin[8.9876]{9}}{\m\cubed\usk\kg\usk\reciprocalquartic\s\usk\A\reciprocalsquared}
836 [\m\per\farad] [\newton\usk\m\squared\per\coulomb\squared]
837 \newcommand{\coulombconstant}{\oofpez}
838 \newphysicsconstant{oofpezcs}{\ensuremath{\frac{1}{\phantom{_o}4\pi\ssub{\epsilon}{o}}}
839 c^2\phi_{o}\}{\scin{-7}}{\mbox{$\s$\ciprocalsquared}} c^2\phi_{o}\}{\scin{-7}}{\mbox{$\s$\ciprocalsquared}} c^2\phi_{o}\}
840 [\T\usk\m\squared] [\N\usk\s\squared\per\C\squared]
841 \newcommand{\altcoulombconstant}{\oofpezcs}
842 \newphysicsconstant{vacuumpermittivity}{\ensuremath{\ssub{\epsilon}{o}}}}{\scin[8.8542]{-12}}
843 {\m\reciprocalcubed\usk\reciprocal\kg\usk\s\quarted\usk\A\squared} [\F\per\m]
844 [\C\squared\per\N\usk\m\squared]
845 \newphysicsconstant{mzofp}{\ensuremath{\frac{\phantom{_oo}\ssub{\mu}{o}\phantom{_o}}}
846 {4\pi}}}{\scin{-7}}{\m\usk\kg\usk\s\reciprocalsquared\usk\A\reciprocalsquared}
847 [\henry\per\m] [\tesla\usk\m\per\A]
848 \newcommand{\biotsavartconstant}{\mzofp}
849 \newphysicsconstant{vacuumpermeability}{\ensuremath{\ssub{\mu}{o}}}{\scin[4\pi]{-7}}}
850 {\m\usk\kg\usk\s\reciprocalsquared\usk\A\reciprocalsquared} [\henry\per\m]
851 [\T\usk\m\per\A]
852 \newphysicsconstant{boltzmann}{\newphysicsconstant{boltzmann}{\newphysicsconstant{boltzmann}{\newphysicsconstant{boltzmann}{\newphysicsconstant{boltzmann}{\newphysicsconstant{boltzmann}{\newphysicsconstant{boltzmann}{\newphysicsconstant{boltzmann}{\newphysicsconstant{boltzmann}{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\newphysicsconstant{\
853 {\m\squared\usk\kg\usk\reciprocalsquare\s\usk\reciprocal\K} [\joule\per\K] [\J\per\K]
854 \newcommand{\boltzmannconstant}{\boltzmann}
855 \newphysicsconstant{boltzmanninev}{\ensuremath{\ssub{k}{B}}}{\scin[8.6173]{-5}}
856 {\eV\usk\reciprocal\K}[\eV\per\K][\eV\per\K]
857 \newphysicsconstant{stefanboltzmann}{\ensuremath{\sigma}}{\scin[5.6704]{-8}}
858 {\kg\usk\s\reciprocalcubed\usk\K\reciprocalquarted} [\W\per\m\squared\usk\K^4]
859 [\W\per\m\squared\usk\K\quarted]
860 \newcommand{\stefanboltzmannconstant}{\stefanboltzmann}
861 \newphysicsconstant{planck}{\ensuremath{h}}{\scin[6.6261]{-34}}
862 \m \ [\J\usk\s] [\J\usk\s]
863 \newcommand{\planckconstant}{\planck}
864 \newphysicsconstant{planckinev}{\ensuremath{h}}{\scin[4.1357]{-15}}
865 {\eV\usk\s} [\eV\usk\s] [\eV\usk\s]
866 \newphysicsconstant{planckbar}{\ensuremath{\hbar}}{\scin[1.0546]{-34}}
867 {\m\squared\usk\kg\usk\reciprocal\s}[\J\usk\s][\J\usk\s]
868 \newcommand{\reducedplanckconstant}{\planckbar}
869 \newphysicsconstant{planckbarinev}{\ensuremath{\hbar}}{\scin[6.5821]{-16}}
870 {\eV}_s [\eV\usk\s] [\eV\usk\s]
871 \newphysicsconstant{planckc}{\ensuremath{hc}}{\scin[1.9864]{-25}}
872 {\m\cubed\usk\kg\usk\reciprocalsquare\s} [\J\usk\m] [\J\usk\m]
873 \newcommand{\planckconstanttimesc}{\planckc}
874 \newphysicsconstant{planckcinev}{\ensuremath{hc}}{\scin[1.9864]{-25}}
875 {\eV\usk\ensuremath{\mathbb{n}\m}}[\eV\usk\ensuremath{\mathbb{n}\m}]
```

```
876 [\eV\usk\ensuremath{\mathrm{n}\m}]
877 \newphysicsconstant{rydberg}{\ensuremath{\msub{R}{\infty}}}{\scin[1.0974]{7}}
878 {\reciprocal\m}[\reciprocal\m][\reciprocal\m]
879 \newcommand{\rydbergconstant}{\rydberg}
880 \newphysicsconstant{bohrradius}{\ensuremath{\msub{a}{0}}}{\scin[5.2918]{-11}}{\m} [\m] [\m]
881 \newphysicsconstant{finestructure}{\ensuremath{\alpha}}{\scin[7.2974]{-3}}{\relax}
882 \newcommand{\finestructureconstant}{\finestructure}
883 \newphysicsconstant{avogadro}{\ensuremath{\ssub{N}{A}}}}{\scin[6.0221]{23}}
884 {\reciprocal\mol}[\reciprocal\mol][\reciprocal\mol]
885 \newcommand{\avogadroconstant}{\avogadro}
886 \newphysicsconstant{universalgrav}{\ensuremath{G}}{\scin[6.6738]{-11}}
887 {\tt \n\cubed\usk\reciprocal\kg\usk\s\reciprocal\squared} \ [\tt \J\usk\m\per\kg\squared]
888 [\N\usk\m\squared\per\kg\squared]
889 \newcommand{\universalgravitationalconstant}{\universalgrav}
890 \newphysicsconstant{surfacegravfield}{\ensuremath{g}}{9.80}{\m\usk\s\reciprocalsquared}
891 [\N\per\kg] [\m\per\s\squared]
892 \newcommand{\earthssurfacegravitationalfield}{\surfacegravfield}
893 \newphysicsconstant{clight}{\ensuremath{c}}{\scin[2.9979]{8}}{\m\usk\reciprocal\s}
894 [\m\per\s] [\m\per\s]
895 \newcommand{\photonconstant}{\clight}
896 \newphysicsconstant{clightinfeet}{\ensuremath{c}}{0.9836}
897 {\ensuremath{\mathrm{ft}\usk\reciprocal\mathrm{n}\s}}
898 [\ensuremath{\mathrm{ft}\per\mathrm{n}\s}] [\ensuremath{\mathrm{ft}\per\mathrm{n}\s}]
899 \newphysicsconstant{Ratom}{\ensuremath{\ssub{r}{atom}}}{\ssub{r}}{\scin{-10}}{\m} [\m] [\m]
900 \newcommand{\radiusofatom}{\Ratom}
901 \newphysicsconstant{Mproton}{\ensuremath{\ssub{m}{proton}}}{\scin[1.6726]{-27}}
902 {\kg} [\kg] [\kg]
903 \newcommand{\massofproton}{\Mproton}
904 \newphysicsconstant{Mneutron}{\ensuremath{\ssub{m}{neutron}}}{\scin[1.6749]{-27}}
905 {\kg} [\kg] [\kg]
906 \newcommand{\massofneutron}{\Mneutron}
907 \newphysicsconstant{Mhydrogen}{\ensuremath{\ssub{m}{hydrogen}}}{\scin[1.6737]{-27}}
908 {\kg} [\kg] [\kg]
909 \newcommand{\massofhydrogen}{\Mhydrogen}
910 \newphysicsconstant{Melectron}{\ensuremath{\ssub{m}{electron}}}\scin[9.1094]{-31}}
911 {\kg}[\kg][\kg]
912 \newcommand{\massofelectron}{\Melectron}
913 \newphysicsconstant{echarge}{\ensuremath{e}}}{\scin[1.6022]{-19}}{\A\usk\s}[\C][\C]
914 \newcommand{\elementarycharge}{\echarge}
915 \newphysicsconstant{Qelectron}{\ensuremath{\ssub{Q}{electron}}}{-\echargevalue}
916 {\A\usk\s}[\C][\C]
917 \newphysicsconstant{qelectron}{\ensuremath{\ssub{q}{electron}}}{-\echargevalue}
918 {\A\usk\s}[\C][\C]
919 \newcommand{\chargeofelectron}{\Qelectron}
920 \newphysicsconstant{Qproton}{\ensuremath{\ssub{Q}{proton}}}{+\echargevalue}
921 {\A\usk\s}[\C][\C]
922 \newphysicsconstant{qproton}{\ensuremath{\ssub{q}{proton}}}{+\echargevalue}
923 {\A\usk\s}[\C][\C]
924 \newcommand{\chargeofproton}{\Qproton}
```

925 \newphysicsconstant{MEarth}{\ensuremath{\ssub{M}{Earth}}}{\scin[5.9736]{24}}{\kg}[\kg][\kg]

```
926 \newcommand{\massofEarth}{\MEarth}
928 \newcommand{\massofMoon}{\MMoon}
929 \newphysicsconstant{MSun}{\ensuremath{\ssub{M}{Sun}}}{\scin[1.9891]{30}}{\kg][\kg][\kg]
930 \newcommand{\massofSun}{\MSun}
931 \newphysicsconstant{REarth}{\ensuremath{\ssub{R}_{Earth}}}{\scin[6.3675]_{6}}_{\m][\m][\m]_
932 \newcommand{\radiusofEarth}{\REarth}
933 \newphysicsconstant{RMoon}{\ensuremath{\ssub{R}{Moon}}}{\scin[1.7375]{6}}{\m}[\m][\m]
934 \newcommand{\radiusofMoon}{\RMoon}
936 \newcommand{\radiusofSun}{\RSun}
937 \newphysicsconstant{ESdist}{\magvectsub{r}{ES}}{\scin[1.4960]{11}}{\m}[\m][\m]
938 \newphysicsconstant{SEdist}{\magvectsub{r}{SE}}{\scin[1.4960]{11}}{\m}[\m][\m]
939 \newcommand{\EarthSundistance}{\ESdist}
940 \newcommand{\SunEarthdistance}{\SEdist}
941 \newphysicsconstant{EMdist}{\magvectsub{r}{EM}}\{sin[3.8440]\{8\}\}\{m][m]
942 \newphysicsconstant{MEdist}{\magvectsub{r}{ME}}{\scin[3.8440]{8}}{\m}[\m][\m]
943 \newcommand{\EarthMoondistance}{\ESdist}
944 \newcommand{\MoonEarthdistance}{\SEdist}
945 \newphysicsconstant{LSun}{\ensuremath{\ssub{L}{Sun}}}{\scin[3.8460]{26}}
     {\m\squared\usk\kg\usk\s\reciprocalcubed}[\W][\J\per\s]
947 \newphysicsconstant{TSun}{\ensuremath{\ssub{T}{Sun}}}{5778}{\K}[\K][\K]
948 \newphysicsconstant{MagSun}{\ensuremath{\ssub{M}{Sun}}}{+4.83}{}[][]
949 \newphysicsconstant{magSun}{\ensuremath{\ssub{m}{Sun}}}{-26.74}{}[][]
950 \newcommand{\Lstar}[1][\(\star\)]{\ensuremath{\ssub{L}{#1}}}
951 \newcommand{\Lsolar}{\ensuremath{\Lstar[\(\odot\)]}}
952 \newcommand{\Tstar}[1][\(\star\)]{\ensuremath{\ssub{T}{#1}}}
953 \newcommand{\Tsolar}{\ensuremath{\Tstar[\(\odot\)]}}
954 \newcommand{\Rstar}[1][\(\star\)]{\ensuremath{\ssub{R}{#1}}}
955 \newcommand{\Rsolar}{\ensuremath{\Rstar[\(\odot\)]}}
956 \newcommand{\Mstar}[1][\(\star\)]{\ensuremath{\ssub{M}{#1}}}
957 \newcommand{\Msolar}{\ensuremath{\Mstar[\(\odot\)]}}
958 \newcommand{\Fstar}[1][\(\star\)]{\ensuremath{\ssub{F}{#1}}}
959 \newcommand{\fstar}[1][\(\star\)]{\ensuremath{\ssub{f}{#1}}}
960 \newcommand{\Fsolar}{\ensuremath{\Fstar[\(\odot\)]}}
961 \newcommand{\fsolar}{\ensuremath{\fstar[\(\odot\)]}}
962 \newcommand{\Magstar}[1][\(\star\)]{\ensuremath{\ssub{M}{#1}}}
963 \newcommand{\magstar}[1][\(\star\)]{\ensuremath{\ssub{m}{#1}}}
964 \newcommand{\Magsolar}{\ensuremath{\Magstar[\(\odot\)]}}
965 \newcommand{\magsolar}{\ensuremath{\magstar[\(\odot\)]}}
966 \newcommand{\Dstar}[1][\(\star\)]{\ensuremath{\ssub{D}{#1}}}
967 \newcommand{\dstar}[1][\(\star\)]{\ensuremath{\ssub{d}{#1}}}
968 \newcommand{\Dsolar}{\ensuremath{\Dstar[\(\odot\)]}}
969 \mbox{\command{\dsolar}{\ensuremath{\dstar[\(\odot\)]}}
970 \newcommand{\onehalf}{\ensuremath{\frac{1}{2}}\xspace}
971 \newcommand{\onethird}{\ensuremath{\frac{1}{3}}\xspace}
972 \newcommand{\onefourth}{\ensuremath{\frac{1}{4}}\xspace}
973 \newcommand{\onefifth}{\ensuremath{\frac{1}{5}}\xspace}
974 \newcommand{\onesixth}{\ensuremath{\frac{1}{6}}\xspace}
975 \newcommand{\oneseventh}{\ensuremath{\frac{1}{7}}\xspace}
```

```
976 \newcommand{\oneeighth}{\ensuremath{\frac{1}{8}}\xspace}
 977 \newcommand{\oneninth}{\ensuremath{\frac{1}{9}}\xspace}
 978 \newcommand{\onetenth}{\ensuremath{\frac{1}{10}}\xspace}
 979 \newcommand{\twooneths}{\ensuremath{\frac{2}{1}}\xspace}
 980 \newcommand{\twohalves}{\ensuremath{\frac{2}{2}}\xspace}
 981 \newcommand{\twothirds}{\ensuremath{\frac{2}{3}}\xspace}
 982 \newcommand{\twofourths}{\ensuremath{\frac{2}{4}}\xspace}
 983 \newcommand{\twofifths}{\ensuremath{\frac{2}{5}}\xspace}
 984 \newcommand{\twosixths}{\ensuremath{\frac{2}{6}}\xspace}
 985 \newcommand{\twosevenths}{\ensuremath{\frac{2}{7}}\xspace}
 986 \newcommand{\twoeighths}{\ensuremath{\frac{2}{8}}\xspace}
 987 \newcommand{\twoninths}{\ensuremath{\frac{2}{9}}\xspace}
 988 \newcommand{\twotenths}{\ensuremath{\frac{2}{10}}\xspace}
 989 \newcommand{\threeoneths}{\ensuremath{\frac{3}{1}}\xspace}
 990 \newcommand{\threehalves}{\ensuremath{\frac{3}{2}}\xspace}
 991 \newcommand{\threethirds}{\ensuremath{\frac{3}{3}}\xspace}
 992 \newcommand{\threefourths}{\ensuremath{\frac{3}{4}}\xspace}
 993 \newcommand{\threefifths}{\ensuremath{\frac{3}{5}}\xspace}
 994 \newcommand{\threesixths}{\ensuremath{\frac{3}{6}}\xspace}
 995 \newcommand{\threesevenths}{\ensuremath{\frac{3}{7}}\xspace}
 996 \newcommand{\threeeighths}{\ensuremath{\frac{3}{8}}\xspace}
 997 \newcommand{\threeninths}{\ensuremath{\frac{3}{9}}\xspace}
 998 \newcommand{\threetenths}{\ensuremath{\frac{3}{10}}\xspace}
 999 \newcommand{\fouroneths}{\ensuremath{\frac{4}{1}}\xspace}
1000 \newcommand{\fourhalves}{\ensuremath{\frac{4}{2}}\xspace}
1001 \newcommand{\fourthirds}{\ensuremath{\frac{4}{3}}\xspace}
1002 \newcommand{\fourfourths}{\ensuremath{\frac{4}{4}}\xspace}
1003 \newcommand{\fourfifths}{\ensuremath{\frac{4}{5}}\xspace}
1004 \newcommand{\foursixths}{\ensuremath{\frac{4}{6}}\xspace}
1005 \newcommand{\foursevenths}{\ensuremath{\frac{4}{7}}\xspace}
1006 \newcommand{\foureighths}{\ensuremath{\frac{4}{8}}\xspace}
1007 \newcommand{\fourninths}{\ensuremath{\frac{4}{9}}}\xspace}
1008 \newcommand{\fourtenths}{\ensuremath{\frac{4}{10}}\xspace}
1009 \newcommand{\dx}[1]{\ensuremath{\, \mathrm{d}{#1}}}
1010 \newcommand{\evalfromto}[3]{\ensuremath{\Bigg.{#1}\Bigg\rvert_{#2}^{#3}}}
1011 \@ifpackageloaded{physymb}{%
          \typeout{mandi: Package physymb detected. Its commands will be used.}
1012
1013 }{%
          \newcommand{\evalat}[2]{\ensuremath{\Bigg.{#1}\Bigg\rvert_{#2}}}
1014
1015 }%
1016 \newcommand{\evaluatedat}[1]{\ensuremath{\Bigg.\Bigg\rvert_{#1}}}
1017 \newcommandx{\integral}[4][1,2,usedefault]{\ensuremath{
          \int_{\left[\frac{42}{2}}{\frac{42=41}}^{\left[\frac{42+4}{2}}}
1019
          {#3}\dx{#4}}
1020 \newcommandx{\Integral}[4][1,2,usedefault]{\ensuremath{
          \begin{array}{ll} \begin{array}{ll} & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & \\ & & \\ & & \\ & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & & \\ & 
1021
1022
          {#4=#2}}{#3}\dx{#4}}
1023 \newcommand{\opensurfintegral}[2]{\ensuremath{
          1025 \newcommand{\opensurfIntegral}[2]{\ensuremath{
```

```
\bigint\nolimits_{\mskip -25.00mu\displaystyle\mathbf{#1}}
1026
1027
               \vectdotvect{\vect{#2}}{\dirvect{n}}}
1028
               /4x{\y}}}
1029 \newcommand{\closedsurfintegral}[2]{\ensuremath{
               \oint\nolimits_{#1}\vectdotvect{\vect{#2}}{\dirvect{n}}\dx{A}}}
1030
1031 \newcommand{\closedsurfIntegral}[2]{\ensuremath{
1032
               \bigoint\nolimits_{\mskip -25.00mu\displaystyle\mathbf{#1}}\;\;
1033
               \vectdotvect{\vect{#2}}{\dirvect{n}}\dx{A}}}
1034 \newcommand{\openlineintegral}[2]{\ensuremath{
1035
               \int\nolimits_{#1}\vectdotvect{\vect{#2}}{\dirvect{t}}
1036
               \dx{\e11}}}
1037 \newcommand{\openlineIntegral}[2]{\ensuremath{
               \bigint\nolimits_{\mskip -25.00mu\displaystyle\mathbf{#1}}
1038
1039
               \vectdotvect{\vect{#2}}{\dirvect{t}}\dx{\ell}}}
1040 \newcommand{\closedlineintegral}[2]{\ensuremath{
               \oint\nolimits_{#1}\vectdotvect{\vect{#2}}{\dirvect{t}}\dx{\ell}}}
1042 \newcommand{\closedlineIntegral}[2]{\ensuremath{
               \bigoint\nolimits_{\mskip -25.00mu\displaystyle\mathbf {#1}}\;\;
               \vectdotvect{\vect{#2}}{\dirvect{t}}\dx{\ell}}}
1044
1045 \end{2} in $\{d}_{1}_{1}_{1}_{1}_{1}^{\infty} \end{2} in $\{d}_{1}}_{1}_{1}_{1}_{1}^{\infty} \end{2} in $\{d}_{1}}_{1}_{1}_{1}^{\infty} \end{2} in $\{d}_{1}_{1}}_{1}_{1}_{1}^{\infty} \end{2} in $\{d}_{1}_{1}_{1}^{\infty} \end{2} in $\{d}_{1}_{1}_{1}^{\infty} \end{2} in $\{d}_{1}_{1}_{1}^{\infty} \end{2} in $\{d}_{1}_{1}_{1}^{\infty} \end{2} in $\{d}_{1}_{1}^{\infty} \end{2} in $\{d}_{1}_{1}^{\infty} \end{2} in $\{d}_{1}_{1}^{\infty} \end{2} in $\{d}_{1}_{1}^{\infty} \end{2} in $\{d}_{1}^{\infty} \end{2} 
1046 \mbox{\DbyDt}[1][1] {\mbox{\propto frac{\propto fr
1047 \end{dbydt} [1] [1] {\ensuremath{frac{\mathbf{d}^{2}{\#1}}{\mathbf{d}t^{2}}}} 
1048 \mbox{DbyDt}[1][1]{\mbox{\mbox{Delta $$^{2}$}$}}\mbox{Delta $$^{2}$}}
1049 \newcommandx{\pbypt}[1][1] {\ensuremath{\frac{\partial{#1}}{\partial t}}}
1050 \mbox{\ppbypt}[1][1] {\mbox{\partial}^{2}{\#1}}{\partial t^{2}}} \}
1051 \end{dbyd} [2] {\ensuremath{\frac{\mathbb{d}{\#1}}{\mathbb{d}{\#2}}}}
1052 \newcommand{\DbyD}[2]{\ensuremath{\frac{\Delta{#1}}{\Delta{#2}}}}
1053 \end{ddbyd} [2] {\ensuremath{frac{\mathbf{d}^{2}{#1}}{\mathbf{d}^{2}}}} 
1054 \mbox{DDbyD}[2]{\mbox{Delta}{2}{#1}}{\Delta{#2}^{2}}}
1055 \newcommand{\pbyp}[2]{\ensuremath{\frac{\partial{#1}}{\partial{#2}}}}
1056 \end{ppbyp} \cite{$\operatorname{2}{\#1}}{\operatorname{2}{\#2}^{2}}} \label{eq:poisson}
1057 \newcommand{\seriesfofx}{\ensuremath{%
1058 f(x) \alpha f(a) + \frac{f^\alpha(f^\beta(x-a) + \frac{f^\alpha(f^\beta(x-a))}{2!}(x-a)^2}{1058 f(x) \alpha f(a)} + \frac{f^\alpha(f^\beta(x-a))^2}{1058 f(x) \alpha f(a)}
1059 + \frac{f^{\left(\frac{f^{\left(\frac{n}{3!}(x-a)^3 + \ldots\right)}}{xspace}}}{1059 + \frac{n}{3!}(x-a)^3 + \dots}}
1060 \newcommand{\seriesexpx}{\ensuremath{%
1061 e^x \exp 1 + x + \frac{x^2}{2!} + \frac{x^3}{3!} + \ldots 
1062 \newcommand{\seriessinx}{\ensuremath{%}}
1063 \sin x \approx x - \frac{x^3{3!} + \frac{x^5{5!} - \ldots\xspace}
1064 \newcommand{\seriescosx}{\ensuremath{%
1065 \cos x \exp 1 - \frac{x^2}{2!} + \frac{x^4}{4!} - \left(\frac{x^4}{4!} - \frac{x^4}{4!}\right)
1066 \newcommand{\seriestanx}{\ensuremath{%
1067 \times x \exp x + \frac{x^3}{3} + \frac{2x^5}{15} + \frac{x \exp x}{2x^5}
1068 \newcommand{\seriesatox}{\ensuremath{%
1069 \ a^x \ approx \ 1 + x \ ln{a} + \ frac{(x \ ln \ a)^2}{2!} + \ frac{(x \ ln \ a)^3}{3!} + \ ldots}
1070 \xspace}
1071 \newcommand{\serieslnoneplusx}{\ensuremath{%
1072 \ln(1 \pm x) \approx \pm\; x - \frac{x^2}{2} \pm \frac{x^3}{3} - \frac{x^4}{4} \pm \ldots}
1073 \xspace}
1074 \newcommand{\binomialseries}{\ensuremath{%
1075 (1 + x)^n \exp x 1 + nx + \frac{n(n-1)}{2!}x^2 + \ldots
```

```
1076 \@ifpackageloaded{physymb}{%
      \typeout{mandi: Package physymb detected. Its commands will be used.}
1078 }{%
      \verb|\newcommand{\gradient}{\nabla}| \\
1079
      \newcommand{\divergence}{\ensuremath{\nabla\bullet}}
1080
1081
      \newcommand{\curl}{\ensuremath{\nabla\times}}
1082
      \newcommand{\laplacian}{\ensuremath{\msup{\nabla}{2}}}
1083
      \newcommand{\dalembertian}{\ensuremath{\Box}}
1084 }%
1085 \newcommand{\diracdelta}[1]{\ensuremath{\boldsymbol{\delta}\quant{#1}}}
1086 \verb|\@ifpackageloaded{physymb}{%}
      \typeout{mandi: Package physymb detected. Its commands will be used.}
1088 }{%
1089 \DeclareMathOperator{\asin}{\sin^{-1}}}
1090 \DeclareMathOperator{\acos}{\cos^{-1}}}
1091 \DeclareMathOperator{\atan}{\tan^{-1}}}
1092 \DeclareMathOperator{\asec}{\sec^{-1}}}
1093 \DeclareMathOperator{\acsc}{\csc^{-1}}}
1094 \DeclareMathOperator{\acot}{\cot^{-1}}}
1095 \DeclareMathOperator{\sech}{sech}
1096 \DeclareMathOperator{\csch}{csch}
1097 \DeclareMathOperator{\asinh}{\sinh^{-1}}}
1098 \DeclareMathOperator{\acosh}{\cosh^{-1}}}
1099 \label{loss} $$1099 \end{$\operatorname{\lambda}_{-1}} 
1101 \DeclareMathOperator{\acsch}{\csch^{-1}}}
1102 \DeclareMathOperator{\acoth}{\coth^{-1}}}
1103 \DeclareMathOperator{\sgn}{sgn}
1104 }%
1105 \DeclareMathOperator{\dex}{dex}
1106 \newcommand{\logb}[1][\relax]{\ensuremath{\log_{_{#1}}}}
1107 \ifthenelse{\boolean{@optitalicvectors}}
      {\newcommand{\cB}{\ensuremath{c\mskip -5.00mu B}}}
      {\newcommand{\cB}{\ensuremath{\textsf{c}\mskip -3.00mu\mathrm{B}}}}
1110 \newcommand{\newpi}{\ensuremath{\pi\mskip -7.8mu\pi}}
1111 \newcommand{\scripty}[1]{\ensuremath{\mathcalligra{#1}}}
1112 \mbox{ lowermandx{\flux}[1][1]{\ensuremath{\ssub{\Phi}{#1}}}
1113 \@ifpackageloaded{physymb}{%
      \typeout{mandi: Package physymb detected. Its commands will be used.}
1114
1115 }{%
      \newcommand{\abs}[1]{\ensuremath{\left\lvert{#1}\right\rvert}}
1116
1117 }%
1118 \newcommand{\magof}[1]{\ensuremath{\left\lVert{#1}\right\rVert}}
1119 \newcommand{\dimsof}[1]{\ensuremath{\left[{#1}\right]}}
1120 \newcommand{\unitsof}[1] {\ensuremath{\left[{#1}\right]_{_{u}}}}
1121 \newcommand{\quant}[1]{\ensuremath{\left({#1}\right)}}
1122 \newcommand{\bquant}[1]{\ensuremath{\left[{#1}\right]}}
1123 \newcommand{\changein}[1]{\ensuremath{\delta{#1}}}
1124 \newcommand{\Changein}[1]{\ensuremath{\Delta{#1}}}
1125 \newcommandx{\scin}[3][1,3=\!\!,usedefault]{\ensuremath{\%}
```

```
\ifthenelse{\equal{#1}{}}
1126
1127
             {\displaystyle \{ \sum_{10} {\#2} \} {\#3} \}}
             {\substack{\{\text{unit}(\text{msup}\{\#1\}\times 10\}\{\#2\}\}\{\#3\}\}}}
1129 \newcommand{\ee}[2]{\texttt{{#1}e{#2}}}
1130 \newcommand{\EE}[2]{\texttt{{#1}E{#2}}}
\label{lower_lower_lower} $$132 \rightarrow {\math{\{\#1\}^{\wedge}}}{\mathrm{m}}{\math{\{\#3\}^{\wedge}}}}
1133 \newcommand{\clockreading}{\hms}
1134 \newcommand{\latitude}[1]{\ensuremath{\unit{#1}{\degree}}}
1135 \newcommand{\latitudeN}[1]{\ensuremath{\unit{#1}}{\degree\;\mathrm{N}}}}
1136 \mbox{\latitudeS} [1] {\mbox{\unit}$\#1}{\degree}; \mbox{\unit}$\#3}}
1137 \newcommand{\longitude}[1]{\ensuremath{\unit{#1}{\degree}}}
1138 \newcommand{\longitudeE}[1]{\ensuremath{\unit{#1}{\degree\;\mathrm{E}}}}
1139 \newcommand{\longitudeW}[1]{\ensuremath{\unit{#1}{\degree\;\mathrm{W}}}}
1140 % I have never liked \LaTeX's default subscript positioning, so I have this
1141 % command instead. There may be a better way of doing this.
1142 \mod{\sub}[2]{\ensuremath{#1}_{_{_{_{_{_{_{_{_{_{1}}}}}}}}}}}}
1143 % I have never liked \LaTeX's default superscript positioning, so I have this
1144 % command instead. There may be a better way of doing this.
1145 \newcommand{\ssup}[2] \{\text{#1}^{^{\infty}}\}}
1146 \newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\newcommand(\sud)[3]{\n
1147 % I have never liked \LaTeX's default subscript positioning, so I have this
1148 % command instead. There may be a better way of doing this.
1150 % I have never liked \LaTeX's default superscript positioning, so I have this
1151 % command instead. There may be a better way of doing this.
1152 \newcommand{\msup}[2]{\ensuremath{#1^{^{\scriptstyle{#2}}}}}
1153 \newcommand{\msud}[3] {\ensuremath{\#1^{^{scriptstyle}}}_{_{_{_{_{_{_{_{_{_{1}}}}}}}}}}
1154 \newcommand{\levicivita}[1]{\ensuremath{\msub{\varepsilon}{#1}}}
1155 \newcommand{\kronecker}[1]{\ensuremath{\msub{\delta}{#1}}}
1156 \newcommand{\xaxis}{\ensuremath{x\mbox{-axis }}}
1157 \newcommand{\yaxis}{\ensuremath{y\mbox{-axis }}}
1158 \newcommand{\zaxis}{\ensuremath{z\mbox{-axis }}}
1159 \newcommand{\naxis}[1]{\ensuremath{{#1}\mbox{-axis}}}
1160 \newcommand{\xyplane}{\ensuremath{xy\mbox{-plane }}}
1161 \newcommand{\yzplane}{\ensuremath{yz\mbox{-plane }}}
1162 \newcommand{\zxplane}{\ensuremath{zx\mbox{-plane }}}
1163 \newcommand{\yxplane}{\ensuremath{yx\mbox{-plane }}}
1164 \newcommand{\zyplane}{\ensuremath{zy\mbox{-plane }}}
1165 \newcommand{\xzplane}{\ensuremath{xz\mbox{-plane }}}
1166 % Frequently used roots. Prepend |f| for fractional exponents.
1167 \newcommand{\cuberoot}[1]{\ensuremath{\sqrt[3]{#1}}}
1168 \newcommand{\fourthroot}[1]{\ensuremath{\sqrt[4]{#1}}}
1169 \newcommand{\fifthroot}[1]{\ensuremath{\sqrt[5]{#1}}}
1170 \newcommand{\fsqrt}[1]{\ensuremath{\msup{#1}{\onehalf}}}
1171 \newcommand{\fcuberoot}[1]{\ensuremath{\msup{#1}{\onethird}}}
1172 \newcommand{\ffourthroot}[1]{\ensuremath{\msup{#1}{\onefourth}}}
1173 \newcommand{\ffifthroot}[1]{\ensuremath{\msup{#1}{\onefifth}}}
1174 \newcommand{\relgamma}[1]{\ensuremath{
         \frac{1}{\sqrt{1-\max{\{1-\max{\{\gamma_{1},\{c\}\}}}}}}
```

```
1176 \newcommand{\frelgamma}[1]{\ensuremath{
     \max_{1-\frac{m\sup\{\#1\}}{2}}{\max\{c}_{2}}}{-\operatorname{lone}()}
1178 \newcommand{\oosgrtomxs}[1]{\ensuremath{\frac{1}{\sqrt{1-\msup{#1}{2}}}}}
1179 \mbox{\command{\cosqrtomx}[1]{\cosqrtomx}[4]}}
1180 \newcommand{\ooomx}[1]{\ensuremath{\frac{1}{1-{#1}}}}
1181 \newcommand{\ooopx}[1]{\newcommand{\temple}}
1182 \newcommand{\isequals}{\wordoperator{?}{=}\xspace}
1183 \newcommand{\wordoperator}[2]{\ensuremath{%
     \mathrel{\vcenter{\offinterlineskip
1185
     \halign{\hfil\tiny\upshape##\hfil\cr\noalign{\vskip-.5ex}
       {#1}\cr\noalign{\vskip.5ex}{#2}\cr}}}
1186
1187 \newcommand{\definedas}{\wordoperator{defined}{as}\xspace}
1188 \newcommand{\associated}{\wordoperator{associated}{\with}\xspace}
1189 \newcommand{\adjustedby}{\wordoperator{adjusted}{by}\xspace}
1190 \newcommand{\earlierthan}{\wordoperator{earlier}{than}\xspace}
1191 \newcommand{\laterthan}{\wordoperator{later}{than}\xspace}
1192 \newcommand{\forevery}{\wordoperator{for}{every}\xspace}
1193 \newcommand{\pwordoperator}[2]{\ensuremath{\left(%
     \mathrel{\vcenter{\offinterlineskip}
1194
     \halign{\hfil\tiny\upshape##\hfil\cr\noalign{\vskip-.5ex}
1195
1196
       {#1}\cr\noalign{\vskip.5ex}{#2}\cr}}\right)}}%
1197 \newcommand{\pdefinedas}{\pwordoperator{defined}{as}\xspace}
1198 \newcommand{\passociated}{\pwordoperator{associated}{\with}\xspace}
1199 \newcommand{\padjustedby}{\pwordoperator{adjusted}{by}\xspace}
1200 \newcommand{\pearlierthan}{\pwordoperator{earlier}{than}\xspace}
1201 \newcommand{\platerthan}{\pwordoperator{later}{than}\xspace}
1202 \newcommand{\pforevery}{\pwordoperator{for}{every}\xspace}
1203 \newcommand{\defines}{\ensuremath{\stackrel{\text{\tiny{def}}}}{=}}\xspace}
1204 \newcommand{\inframe}[1][\relax]{\ensuremath{\xrightarrow[\text\tiny{\mathcal #1}]{}}\xspace}
1205 \newcommand{\associates}{\ensuremath{\xrightarrow{\text{\tiny{assoc}}}}}\xspace}
1206 \newcommand{\becomes}{\ensuremath{\xrightarrow{\text{\tiny{becomes}}}}\xspace}
1207 \newcommand{\rrelatedto}[1]{\ensuremath{\xLongrightarrow{\text{\tiny{#1}}}}}
1208 \newcommand{\lrelatedto}[1]{\ensuremath{\xLongleftarrow[\text{\tiny{#1}}]{}}}
1209 \newcommand{\brelatedto}[2]{\ensuremath{%
     \xLongleftrightarrow[\text{\tiny{#1}}]{\text{\tiny{#2}}}}}
1211 \newcommand{\momentumprinciple}{\ensuremath{
     \vectsub{p}{sys,f}=\vectsub{p}{sys,i}+\Fnetsys\Delta t}}
1212
1213 \newcommand{\LHSmomentumprinciple}{\ensuremath{%
     \vectsub{p}{sys,f}}}
1214
1215 \newcommand{\RHSmomentumprinciple}{\ensuremath{%
     \vectsub{p}{sys,i}+\Fnetsys\Delta t}}
1217 \rightarrow \{\{sys, f\}=\
     \start {W}{ext}+Q}
1219 \newcommand{\LHSenergyprinciple}{\ensuremath{\ssub{E}{sys,f}}}
1221 \newcommand{\angularmomentumprinciple}{\ensuremath{\vectsub{L}{sys,A,f}=
     \vectsub{L}{sys,A,i}+\Tnetsys\Delta t}}
1223 \newcommand{\LHSangularmomentumprinciple}{\ensuremath{\vectsub{L}{sys,A,f}}}
1224 \ensuremath{\klSangularmomentumprinciple}{\ensuremath{\location{L}{sys,A,i}+}}
     \Tnetsys\Delta t}}
1225
```

```
1226 \newcommand{\gravitationalinteraction}{\ensuremath{%
          \label{local-manufaction} $$ \sup^{M}_{1}\msub_{M}_{2}}{\msup_{magvectsub_{1}_{2}}_{2}} $$
          \quant{-\dirvectsub{r}{12}}}
1229 \newcommand{\electricinteraction}{\ensuremath{\%
          \label{loss} $$\operatorname{Q}_{1}\ \sup_{\max_{1}^{12}}{2}} \
1230
1231
          \dirvectsub{r}{12}}}
1232 \newcommand{\Bfieldofparticle}{\ensuremath{%
          \label{local_magnet} $$\max \int_{\mathbb{Q}^{\infty}}{\max \{r}}{2}}\dirvect{v}\times dirvect{r}}}
1234 \newcommand{\Efieldofparticle}{\ensuremath{%
1235
          \operatorname{Q}{\max\{Q}{\max\{r}}{2}\right
1236 \mbox{$\ensuremath{\tt LSys}{\sub{E}{sys}}$}
1237 \end{area} $\{Us\}[1][1]_{\sub{\sub{U}}\{s\}}\{\#1\}\}$
1238 \newcommandx{\Ug}[1][1]{\ssub{\ssub{U}{g}}{#1}}
1239 \newcommandx{Ue}[1][1]{\sub{\ssub{U}{e}}{#1}}
1240 \newcommandx{Ktrans}[1][1]{\ssub{K}{trans}}{#1}}
1241 \newcommandx{Krot}[1][1]{\ssub{K}{rot}}{#1}}
1242 \newcommandx{\Eparticle}[1][1]{\ssub{E}{particle}}{#1}}
1243 \newcommandx{\Einternal}[1][1][\ssub{\ssub{E}{internal}}{#1}}
1244 \model{Erest}[1][1]{\ssub{E}{rest}}{#1}}
1245 \mbox{ \ensuremath{\mbox{Echem}[1][1]{\ssub{\ssub{E}}{chem}}{#1}}
1246 \newcommandx{Etherm}[1][1]{\ssub{E}{therm}}{#1}}
1247 \mbox{Evib}[1][1]{\ssub{E}{vib}}{\#1}}
1248 \mbox{Ephoton}[1][1]{\sub{\ssub{E}{photon}}{#1}}
1249 \verb|\newcommand{\DEsys}{\Changein\Esys}|
1250 \newcommand{\DUs}{\Changein\Us}
1251 \newcommand{\DUg}{\Changein\Ug}
1252 \newcommand{\DUe}{\Changein\Ue}
1253 \newcommand{\DKtrans}{\Changein\Ktrans}
1254 \newcommand{\DKrot}{\Changein\Krot}
1255 \newcommand{\DEparticle}{\Changein\Eparticle}
1256 \newcommand{\DEinternal}{\Changein\Einternal}
1257 \newcommand{\DErest}{\Changein\Erest}
1258 \newcommand{\DEchem}{\Changein\Echem}
1259 \newcommand{\DEtherm}{\Changein\Etherm}
1260 \newcommand{\DEvib}{\Changein\Evib}
1261 \newcommand{\DEphoton}{\Changein\Ephoton}
1262 \mode \Missing \Missing
\label{left(nehalf} $$1263 \neq \frac{\Usinitial}{\sub{\left( nehalf\ks \msup{s}{2}\right)}{i}}{i}}
{\text{magvectsub}\{r\}\{12\}\}}
1265
\label{left-Gfrac} $$1266 \rightarrow {\Uginitial}{\quad -G\frac{\mathbb{M}_{1}\mathbb{M}_{2}}$$}
          {\text{magvectsub}\{r\}\{12\}\}\}
       \label{left(oofpezmathsymbol\frac{\sub{Q}{1}\sub{Q}{2}}} \label{left(oofpezmathsymbol\frac{\sub{Q}{1}\sub{Q}{2}}}
1268
          {\text{magvectsub}\{r\}\{12\}}\right)
1269
\label{left(oofpezmathsymbol)frac(ssub{Q}{1})ssub{Q}{2}} \\
1271
          {\text{magvectsub}\{r\}\{12\}\}}
1272 \mbox{ \newcommand{\ks}{\sub{k}{s}}}
1273 \newcommand{\Fnet}{\ensuremath{\vectsub{F}{\net}}}
1274 \mbox{ } {\mbox{ensuremath{\vectsub{F}{net,ext}}}}
1275 \newcommand{\Fnetsys}{\ensuremath{\vectsub{F}{net,sys}}}
```

```
1276 \mbox{ } [1] {\mbox{vectsub}{F}{\#1}}
1277 \newcommand{\Tnet}{\ensuremath{\vectsub{T}{net}}}
1278 \newcommand{\Tnetext}{\ensuremath{\vectsub{T}{net,ext}}}
1279 \newcommand{\Tnetsys}{\ensuremath{\vectsub{T}{net,sys}}}
1280 \mbox{newcommand}{Tsub}[1]{\mbox{vectsub}{T}{\#1}}}
1281 \newcommand{\vpythonline}{\lstinline[language=Python,numbers=left,numberstyle=\tiny,%
     upquote=true,breaklines]}
1283 \lstnewenvironment{vpythonblock}{\lstvpython}{}
1284 \newcommand{\vpythonfile}{\lstinputlisting[language=Python,numbers=left,%
      numberstyle=\tiny,upquote=true,breaklines]}
1286 \newcommandx{\emptyanswer}[2][1=0.80,2=0.1,usedefault]
      1287
1288 \newenvironmentx{activityanswer}[5][1=white,2=black,3=black,4=0.90,5=0.10,usedefault]{%
1289
      \def\skipper{#5}%
      \def\response@fbox{\fcolorbox{#2}{#1}}%
1290
      \begin{center}%
1291
        \begin{lrbox}{\@tempboxa}%
1292
          \begin{minipage}[c][#5\textheight][c]{#4\textwidth}\color{#3}%
1293
            \vspace{#5\textheight}}{%
1294
1295
            \vspace{\skipper\textheight}%
1296
          \end{minipage}%
1297
        \end{lrbox}%
        \response@fbox{\usebox{\@tempboxa}}%
1298
      \end{center}%
1299
1300 }%
1301 \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}}%
1304
1305
      \begin{center}%
        \begin{lrbox}{\@tempboxa}%
1306
          \begin{minipage}[c]{#4\textwidth}\color{#3}%
1307
            \vspace{#5\textheight}}{%
1308
1309
            \vspace{\skipper\textheight}%
1310
          \end{minipage}%
1311
        \end{lrbox}%
        \response@fbox{\usebox{\@tempboxa}}%
1312
      \end{center}%
1313
1314 }%
1315 \newcommandx{\emptybox}[6][1=\hfill,2=white,3=black,4=black,5=0.90,6=0.10,usedefault]
      {\begin{center}%
1316
         \fcolorbox{#3}{#2}{%
1317
           \begin{minipage}[c][#6\textheight][c]{#5\textwidth}\color{#4}%
1318
             {#1}%
1319
           \end{minipage}}%
1320
         \vspace{\baselineskip}%
1321
1322
       \end{center}%
1323 }%
1324 \newcommandx{\adjemptybox}[7][1=\hfill,2=white,3=black,4=black,5=0.90,6=,7=0.0,usedefault]
      {\begin{center}%
1325
```

```
\fcolorbox{#3}{#2}{%
1326
           \begin{minipage}[c]{#5\textwidth}\color{#4}%
1327
             \vspace{#7\textheight}%
1328
               {#1}%
1329
             \vspace{#7\textheight}%
1330
           \end{minipage}}%
1331
         \vspace{\baselineskip}%
1332
1333
       \end{center}%
1334 }%
1335 \newcommandx{\answerbox}[6][1=\hfill,2=white,3=black,4=black,5=0.90,6=0.1,usedefault]
      {\left( {\frac{\#1}{8}} \right)}
1336
        {\begin{center}%
1337
           \fcolorbox{#3}{#2}{%
1338
             \emptyanswer[#5][#6]}%
1339
1340
         \vspace{\baselineskip}%
1341
         \end{center}}%
1342
        {\emptybox[#1][#2][#3][#4][#5][#6]}%
1343 }%
1344 \newcommandx{\adjanswerbox}[7][1=\hfill,2=white,3=black,4=black,5=0.90,6=0.1,7=0.0,%
      usedefault]%
1345
1346
      1347
        {\begin{center}%
           \fcolorbox{#3}{#2}{%
1348
             \emptyanswer[#5][#6]}%
1349
         \vspace{\baselineskip}%
1350
         \end{center}}%
1351
        {\adjemptybox[#1][#2][#3][#4][#5][#6][#7]}%
1352
1353 }%
1354 \newcommandx{\smallanswerbox}[6][1=\hfill,2=white,3=black,4=black,5=0.90,6=0.10,%
      usedefault]%
1355
      1356
        {\begin{center}%
1357
           \fcolorbox{#3}{#2}{%
1358
1359
             \emptyanswer[#5][#6]}%
1360
         \vspace{\baselineskip}%
         \end{center}}%
1361
        {\emptybox[#1][#2][#3][#4][#5][#6]}%
1362
1363 }%
1364 \mbox{\mbox} [6] [1=\mbox{\mbox}, 2=\mbox{\mbox}, 4=\mbox{\mbox}, 4=\mbox{\mbox}, 5=0.90, 6=0.20, \%
      usedefault]{%
1365
      \ifthenelse{\equal{#1}{}}%
1366
        {\begin{center}%
1367
           \fcolorbox{#3}{#2}{%
1368
             \emptyanswer[#5][#6]%
1369
           }%
1370
         \vspace{\baselineskip}%
1371
         \end{center}%
1372
1373
        {\emptybox[#1][#2][#3][#4][#5][#6]%
1374
1375
```

```
1376 }%
1377 \newcommandx{\largeanswerbox}[6][1=\hfill,2=white,3=black,4=black,5=0.90,6=0.25,%
      usedefault]{%
      \left( \frac{\#1}{{}}\right) 
1379
        {\begin{center}%
1380
            \fcolorbox{#3}{#2}{%
1381
              \emptyanswer[#5][#6]%
1382
1383
1384
          \vspace{\baselineskip}%
          \end{center}%
1385
1386
        {\emptybox[#1][#2][#3][#4][#5][#6]%
1387
        }%
1388
1389 }%
1390 \newcommandx{\largeranswerbox}[6][1=\hfill,2=white,3=black,4=black,5=0.90,6=0.33,%
      usedefault]{%
1391
      \left\{ \left( \#1 \right) \right\}
1392
        {\begin{center}%
1393
            \fcolorbox{#3}{#2}{%
1394
              \emptyanswer[#5][#6]%
1395
1396
1397
          \vspace{\baselineskip}%
          \end{center}%
1398
1399
        {\emptybox[#1][#2][#3][#4][#5][#6]%
1400
1401
1402 }%
1403 \newcommandx{\hugeanswerbox}[6][1=\hfill,2=white,3=black,4=black,5=0.90,6=0.50,%
      usedefault]{%
      \left\{ \left( \frac{\#1}{4} \right) \right\}
1405
1406
        {\begin{center}%
            \fcolorbox{#3}{#2}{%
1407
              \emptyanswer[#5][#6]%
1408
1409
1410
          \vspace{\baselineskip}%
          \end{center}%
1411
1412
        {\emptybox[#1][#2][#3][#4][#5][#6]%
1413
1414
1415 }%
1416 \newcommandx{\hugeranswerbox}[6][1=\hfill,2=white,3=black,4=black,5=0.90,6=0.75,%
      usedefault]{%
      \left\{ \left( \frac{\#1}{\$} \right) \right\}
1418
        {\begin{center}%
1419
            \fcolorbox{#3}{#2}{%
1420
              \emptyanswer[#5][#6]%
1421
1422
          \vspace{\baselineskip}%
1423
          \end{center}%
1424
1425
```

```
{\emptybox[#1][#2][#3][#4][#5][#6]%
1426
1427
1428 }%
1429 \newcommandx{\fullpageanswerbox}[6][1=\hfill,2=white,3=black,4=black,5=0.90,6=1.00,%
      usedefault]{%
1430
      \left\{ \left( \frac{\#1}{{}}\right) \right\} 
1431
        {\begin{center}%
1432
1433
           \fcolorbox{#3}{#2}{%
1434
             \emptyanswer[#5][#6]}%
1435
         \vspace{\baselineskip}%
         \end{center}}%
1436
        {\emptybox[#1][#2][#3][#4][#5][#6]}%
1437
1438 }%
1439 \mdfdefinestyle{miinstructornotestyle}{%
        hidealllines=false, skipbelow=\baselineskip, skipabove=\baselineskip,
1440
        leftmargin=40pt, rightmargin=40pt, linewidth=1, roundcorner=10,
1441
        frametitle={INSTRUCTOR NOTE},
1442
        frametitlebackgroundcolor=cyan!60, frametitlerule=true, frametitlerulewidth=1,
1443
        backgroundcolor=cyan!25,
1444
        linecolor=black, fontcolor=black, shadow=true}
1445
1446 \NewEnviron{miinstructornote}{%
      \begin{mdframed}[style=miinstructornotestyle]
        \begin{adjactivityanswer}[cyan!25][cyan!25][black]
1448
1449
        \end{adjactivityanswer}
1450
      \end{mdframed}
1451
1452 }%
1453 \mdfdefinestyle{mistudentnotestyle}{%
        hidealllines=false, skipbelow=\baselineskip, skipabove=\baselineskip,
1454
        leftmargin=40pt, rightmargin=40pt, linewidth=1, roundcorner=10,
1455
        frametitle={STUDENT NOTE},
1456
        frametitlebackgroundcolor=cyan!60, frametitlerule=true, frametitlerulewidth=1,
1457
1458
        backgroundcolor=cyan!25,
        linecolor=black, fontcolor=black, shadow=true}
1460 \NewEnviron{mistudentnote}{%
      \begin{mdframed}[style=mistudentnotestyle]
1461
        \begin{adjactivityanswer}[cyan!25][cyan!25][black]
1462
          \BODY
1463
        \end{adjactivityanswer}
1464
      \end{mdframed}
1465
1466 }%
1467 \mdfdefinestyle{miderivationstyle}{%
        hidealllines=false, skipbelow=\baselineskip, skipabove=\baselineskip,
1468
        leftmargin=0pt, rightmargin=0pt, linewidth=1, roundcorner=10,
1469
        frametitle={DERIVATION},
1470
        frametitlebackgroundcolor=orange!60, frametitlerule=true, frametitlerulewidth=1,
1471
1472
        backgroundcolor=orange!25,
        linecolor=black, fontcolor=black, shadow=true}
1474 \NewEnviron{miderivation}{%
      \begin{mdframed}[style=miderivationstyle]
```

```
\setcounter{equation}{0}
1476
1477
        \begin{align*}
          \BODY
1478
        \end{align*}
1479
      \end{mdframed}
1480
1481 }%
1482 \mdfdefinestyle{bwinstructornotestyle}{%
        hidealllines=false, skipbelow=\baselineskip, skipabove=\baselineskip,
1484
        leftmargin=40pt, rightmargin=40pt, linewidth=1, roundcorner=10,
        frametitle={INSTRUCTOR NOTE},
1485
        frametitlebackgroundcolor=gray!50, frametitlerule=true, frametitlerulewidth=1,
1486
        backgroundcolor=gray!20,
1487
        linecolor=black, fontcolor=black, shadow=true}
1488
1489 \NewEnviron{bwinstructornote}{%
      \begin{mdframed}[style=bwinstructornotestyle]
        \begin{adjactivityanswer}[gray!20][gray!20][black]
1491
1492
          \BODY
        \end{adjactivityanswer}
1493
      \end{mdframed}
1494
1495 }%
1496 \mdfdefinestyle{bwstudentnotestyle}{%
1497
        hidealllines=false, skipbelow=\baselineskip, skipabove=\baselineskip,
        leftmargin=40pt, rightmargin=40pt, linewidth=1, roundcorner=10,
1498
        frametitle={STUDENT NOTE},
1499
        frametitlebackgroundcolor=gray!50, frametitlerule=true, frametitlerulewidth=1,
1500
        backgroundcolor=gray!20,
1501
        linecolor=black, fontcolor=black, shadow=true}
1502
1503 \NewEnviron{bwstudentnote}{%
      \begin{mdframed}[style=bwstudentnotestyle]
        \begin{adjactivityanswer}[gray!20][gray!20][black]
1505
1506
        \end{adjactivityanswer}
1507
      \end{mdframed}
1508
1509 }%
1510 \mdfdefinestyle{bwderivationstyle}{%
        hidealllines=false, skipbelow=\baselineskip, skipabove=\baselineskip,
1511
        leftmargin=0pt, rightmargin=0pt, linewidth=1, roundcorner=10,
1512
        frametitle={DERIVATION},
1513
        frametitlebackgroundcolor=gray!50, frametitlerule=true, frametitlerulewidth=1,
1514
1515
        backgroundcolor=gray!20,
        linecolor=black, fontcolor=black, shadow=true}
1516
1517 \NewEnviron{bwderivation}{%
      \begin{mdframed}[style=bwderivationstyle]
1518
      \setcounter{equation}{0}
1519
        \begin{align*}
1520
          \BODY
1521
1522
        \end{align*}
1523
      \end{mdframed}
1525 \newcommand{\checkpoint}{%
```

```
\vspace{1cm}\begin{center}|----- CHECKPOINT -----|\end{center}}%
1527 \newcommand{\image}[2]{%
      \begin{figure}[h!]
1528
        \begin{center}%
1529
          \includegraphics[scale=1]{#1}%
1530
1531
          \caption{#2}%
1532
          \label{#1}%
1533
        \end{center}%
1534
      \end{figure}}
1535 \newcommand{\sneakyone}[1]{\ensuremath{\cancelto{1}{\frac{#1}{#1}}}}
1536 % undocumented diagnostic command
1537 \newcommand{\chkquantity}[1]{%
      \begin{center}
1538
        \begin{tabular}{C{3cm} C{3cm} C{3cm} C{3cm}}
1539
                  & baseunit & drvdunit & tradunit \tabularnewline
1540
          \cs{#1} & \csname #1onlybaseunit\endcsname & \csname #1onlydrvdunit\endcsname &
1541
            \csname #1onlytradunit\endcsname
1542
        \end{tabular}
1543
      \end{center}
1544
1545 }%
1546 % undocumented diagnostic command
1547 \newcommand{\chkconstant}[1]{%
1548
      \begin{center}
        \begin{tabular}{C{3cm} C{1cm} C{2cm} C{3cm} C{3cm} C{3cm}}
1549
                  & symbol & value & baseunit & drvdunit & tradunit \tabularnewline
1550
          \cs{#1} & \csname #1mathsymbol\endcsname & \csname #1value\endcsname &
1551
1552
            \csname #1onlybaseunit\endcsname & \csname #1onlydrvdunit\endcsname &
            \csname #1onlytradunit\endcsname
1553
        \end{tabular}
1554
1555
      \end{center}
1556 }%
1557 % new |\vect| that allows for subscripts
1558 % #1 = kernel #2 = subscript
1559 \newcommandx{\vecto}[2][2,usedefault]{\ensuremath{%
1560
     \ifthenelse{\equal{#2}{}}%
        {\vec{#1}}%
1561
1562
        {\sub{\vec{#1}}{\#2}}}%
1563 % new |\compvect| that allows for subscripts
1564 % #1 = kernel #2 = component #3 = subscript
1565 \newcommandx{\compvecto}[3][3,usedefault]{\ensuremath{%
     \ifthenelse{\equal{#3}{}}%
        {\sub{#1}{\(#2\)}}%
1567
1568
        {\sub{#1}{\(#2\),#3}}}%
1569 \% new |\scompsvect| that allows for subscripts
1570 \% #1 = kernel #2 = subscript
1571 \newcommandx{\scompsvecto}[2][2,usedefault]{\ensuremath{%
1572
     \ifthenelse{\equal{#2}{}}%
1573
        {\vcompvecto{\#1}{x},\compvecto{\#1}{y},\compvecto{\#1}{z}\rv}
        {\z}[#2],\compvecto{#1}{y}[#2],\compvecto{#1}{z}[#2]\rv}}
1575 % new |\comppos| that allows for subscripts
```

```
1576 \newcommandx{\compposo}[2][2,usedefault]{\ensuremath{\%}}
1577 \% #1 = component #2 = subscript
     \ifthenelse{\equal{#1}{}}%
1579
       {#1}%
1580
       {\sub{#1}{\#2}}}%
1581\;\text{\%} new |\scompspos| that allows for subscripts
1582 % #1 = subscript
1583 \newcommandx{\scompsposo}[1][1,usedefault]{\ensuremath{\%}}
     \ifthenelse{\equal{#1}{}}%
1584
       \label{lem:comppose} $$ \sup_{x}, \varepsilon_{y}, \varepsilon_{z}\rv}%
1585
1586
```

7 Acknowledgements

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