

The mandi package

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Change History

v2.4.0	General: <code>\vpythonblock</code> now uses a uniform style.	87	<code>\mysolution</code> now prints line numbers.	100
	<code>\vpythonfile</code> now uses a uniform style.	88	<code>\unitsof</code> now shows a placeholder for a blank argument.	67
	<code>\vpythonline</code> now uses a uniform style.	87	<code>\vpythonfile</code> now begins listings on a new page.	88
	Added Lorentz force, with and without magnetic monopoles.	87	Added <code>\bwderivation*</code> to suppress line numbers.	100
	Added magnetic charge.	25	Added <code>\compdirvect.</code>	34
	Added Maxwell's equations in both integral and differential forms, both with and without magnetic monopoles.	78	Added <code>\componentalong.</code>	32
	Added option for approximate values of constants.	7	Added <code>\eulerlagrange</code> command to typeset the Euler-Lagrange equation.	87
	Added option for boldface vector kernels.	7	Added <code>\expcomponentalong.</code>	32
	Added table of all predefined constants with their symbols and units.	57	Added <code>\expprojectiononto.</code>	33
	Added table of all predefined quantities with their units.	27	Added <code>\inparens</code> for grouping with parentheses.	67
	Made option names consistent with default behavior.	7	Added <code>\Lagr</code> to get symbol for Lagrangian.	66
	Now coexists with the <code>commath</code> package.	7	Added <code>\miderivation*</code> to suppress line numbers.	97
	Removed compatibility check for the <code>physymb</code> package.	7	Added <code>\mysolution*</code> to suppress line numbers.	100
v2.4.1	General: <code>\vpythonblock</code> now accepts an optional caption.	87	Added <code>\projectiononto.</code>	32
	<code>\vpythonfile</code> now accepts an optional caption.	88	Added <code>\qed</code> symbol.	102
	Added <code>\scompsCvect</code> for superscripted components.	47	Added <code>\scompsdirvect.</code>	34
	Added <code>\scompsRvect</code> for superscripted components.	47	Added <code>\taigrad</code> to get Tai's curl symbol.	63
	Added more VPython keywords.	87	Added <code>\taigrad</code> to get Tai's divergence symbol.	63
	Commands that use <code>mdframed</code> will not break over pages.	95	Added <code>\taigrad</code> to get Tai's gradient symbol.	63
v2.4.2	General: Added <code>\fullpageanswerform.</code>	95	Added <code>\taisvec</code> to get Tai's symbolic vector.	63
	Added <code>\hugeanswerform.</code>	94	Added <code>\ucomponentalong.</code>	32
	Added <code>\hugeranswerform.</code>	94	Added <code>\ueuzero</code> and friends.	45
	Added <code>\largeanswerform.</code>	94	Added <code>\uprojectiononto.</code>	33
	Added <code>\largeranswerform.</code>	94	Added <code>color</code> to <code>\checkpoint.</code>	102
	Added <code>\mediumanswerform.</code>	94	Added commands for Dirac notation.	47
	Added <code>\smallanswerform.</code>	93	Added example showing how to handle long lines and suppressing numbers on broken lines.	100
v2.5.0	General: <code>\absof</code> now shows a placeholder for a blank argument.	67	Added explicit mention of VPython and GlowScript.	87
	<code>\bwderivation</code> now shows line numbers.	100	Added GlowScript keywords.	87
	<code>\dimsof</code> now shows a placeholder for a blank argument.	67	Added option for radians in certain angular quantities.	7
	<code>\magof</code> now shows a placeholder for a blank argument.	67	Changed behavior of <code>\sneakyone.</code>	102
	<code>\miderivation</code> now prints line numbers.	97	Documented precise and approximate constant values.	49
			Fixed parentheses bug in <code>\magvectncomps.</code>	33
			Removed autosized parentheses in math mode.	7
			Removed compatibility check for the <code>commath</code> package.	7
			Renamed <code>\abs</code> to <code>\absof.</code>	67
v2.5.1	General: Fixed errors in build for uploading to CTAN.	7		

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1 Introduction

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

There are other underlying philosophies and goals embedded within `mandi`, all of which are summarized here. These philosophies 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 pdf \LaTeX , which creates PDF files as output, to build the documentation. I have not tested the build with standard \LaTeX , 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 six available options, with one option being based on the absence of two of the others. The options are described below.

- **boldvectors** gives bold letters for the kernels of vector names. No arrows are used above the kernel.
- **romanvectors** gives Roman letters for the kernels of vectors names. An arrow appears over the kernel.
- If neither **boldvectors** nor **romanvectors** is specified (the default), vectors are displayed with italic letters for the kernels of vector names and an arrow appears over the kernel.
- **singleabsbars** gives single bars in symbols for vector magnitudes. Double bars may be more familiar to students from their calculus courses. Double bars is the default.
- **approxconsts** gives approximate values of constants to one or two significant figures, depending on how they appear in *Matter & Interactions*. Otherwise, the most precise currently available values are used. Precise constants is the default.
- **useradians** gives radians in the units of angular momentum, angular impulse, and torque. The default is to not use radians in the units of these quantities.
- **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`. The two are designed for different purposes and probably also for different audiences, but can be used together if desired. `mandi` coexists with the `commath` package. There is no longer a conflict because `mandi`'s `\abs` command has been renamed to `\absof`. `mandi` no longer checks for the presence of the `physymb` package. That package now incorporates `mandi` dependencies, and the two are completely compatible.

4 Usage

So what does `mandi` allow you to do? There are two main design goals. The first is typeset numerical values of scalar and vector physical quantities and their SI units. The idea is to simply type a command corresponding to the quantity's name, specifying as an argument a single scalar value or the numerical components of a traditional Cartesian 3-vector, and let `mandi` take care of the units.

In introductory physics courses, students typically have trouble remembering which units go with which quantities and, more importantly, remembering to include units in numerical calculations. `mandi` is designed to help with these problems. 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

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

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

which is nearly incomprehensible for people new to \LaTeX and that (probably) includes introductory physics students, but `mandi` lets you do something more logical and more readable, like this

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

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

which produces the same output. In the second example, note that the units are abstracted so the user need not remember them. This doesn't mean that students don't need to know what the various units are, but it does mean that now there is no way for units to be left out of a calculation. Note also that the commands correspond to the actual names of the quantities needed for the calculation. All the student needs to do is remember what quantities are needed and then construct the appropriate \LaTeX expression in a way that is very similar to writing program code in a language like Python, with which many students will have had previous experience. This may make \LaTeX easier for beginners to learn, and 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 (3, 2, 5) kg · 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.

The second main design goal provides a similar approach to typesetting the most frequently used symbolic expressions in introductory physics. If you want to save time in writing out the expression for the electric field of a particle, just use

```
\Efieldofparticle
```

$$\frac{1}{4\pi\epsilon_0} \frac{Q}{\|\vec{r}\|^2} \hat{r}$$

which, as you can see, takes fewer keystrokes and it's easier to remember. Correct vector notation is automatically enforced, leading students to get used to seeing it and, hopefully, using it in their own calculations. Yes, this is a bit of an agenda on my part, but my experience has been that students don't recognize or appreciate the utility of vector notation and thus their physical reasoning may suffer as a result. So by using `mandi` they use simple commands that mirror what they're thinking, or what they're supposed to be thinking (yes, another agenda), and in the process see the correct typeset output.

There is another persistent problem with introductory physics textbooks, and that is that many authors do not use consistent notation. Many authors define the notation for a vector's magnitude to be either $\|\vec{a}\|$ or $|\vec{a}|$ in an early chapter, but then completely ignore that notation and simply use a later in the book. I have never understood the (lack of) logic behind this practice and find it more than annoying. Textbooks authors should know better, and should set a better example for introductory students. I propose that using `mandi` would eliminate all last vestiges of all excuses for not setting this one good example for introductory students.

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

5 Features and Commands

5.1 Autosized Parentheses Removed

An experimental feature of past `mandi` versions was autosized parentheses in math mode. This feature has been removed, mostly because parentheses and some other delimiters have been replaced by commands that leave placeholders if the argument is empty. Autosized parentheses may return in a future version.

5.2 SI Base Units and Dimensions

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 *drdunits* form.

5.3 SI Dimensions

For each SI unit, there is a corresponding dimension. Every physical quantity is some multiplicative product of each of the seven basic SI dimensions raised to a power.

`\dimddisplacement`

Command for the symbol for the dimension of displacement.

displacement has dimension of `\dimdisplacement`

displacement has dimension of L

`\dimmass`

Command for the symbol for the dimension of mass.

mass has dimension of `\dimmass`

mass has dimension of M

`\dimduration`

Command for the symbol for the dimension of duration.

duration has dimension of `\dimduration`

duration has dimension of T

`\dimcurrent`

Command for the symbol for the dimension of current.

current has dimension of `\dimcurrent`

current has dimension of I

`\dimtemperature`

Command for the symbol for the dimension of temperature.

temperature has dimension of `\dimtemperature`

temperature has dimension of Θ

`\dimamount`

Command for the symbol for the dimension of amount.

amount has dimension of `\dimamount`

amount has dimension of N

`\dimluminous`

Command for the symbol for the dimension of luminous intensity.

luminous has dimension of `\dimluminous`

luminous has dimension of J

5.4 Defining Physics Quantities

`\newphysicsquantity`{*newname*}{*baseunits*}[*drvdunits*][*tradunits*]

Defines a new physics quantity and its associated commands.

Using this command causes several things to happen.

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

As an example, consider momentum. The following commands are defined:

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

Momentum is a vector quantity, so obviously this command really refers to the magnitude of a momentum vector. There is an interesting, and as far as I can tell unwritten, convention in physics that we use the same name for a vector and its magnitude with one exception, and that is for velocity, the magnitude of which we sometimes call speed. Conceptually, however, velocity and speed are different entities. Therefore, `mandi` has different commands for them. Actually, the `\speed` command is just an alias for `\velocity` and should only be used for scalars and never for vectors. This convention means that the same name is used for vector quantities and the corresponding magnitudes.

5.4.1 Defining Vector Quantities

All physical quantities are defined as in the momentum example above regardless of whether the quantity is a scalar or a vector. To typeset a vector quantity in terms of its components in some coordinate system (usually an orthonormal cartesian system, specify an argument consisting of a vector with components as a comma separated list in a `\mivector` command. So specifying a momentum vector is as simple as

```
\momentum{\mivector{3,2,-1}}
-----
⟨3, 2, -1⟩ kg · m/s
```

where the notation corresponds to that used in *Matter & Interactions*.

5.5 First Semester Physics

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

5.5.1 Predefined Quantities

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

`\displacement{⟨magnitude⟩}`

Command for displacement.

a displacement of <code>\displacement{5}</code> \\	a displacement of 5 m
a displacement of <code>\displacement{\mivector{3,2,-1}}</code>	a displacement of ⟨3, 2, -1⟩ m

`\mass{<magnitude>}`

Command for mass.

a mass of `\mass{5}`

a mass of 5 kg

`\duration{<magnitude>}`

Command for duration.

a duration of `\duration{5}`

a duration of 5 s

`\current{<magnitude>}`

Command for current.

a current of `\current{5}`

a current of 5 A

`\temperature{<magnitude>}`

Command for temperature.

a temperature of `\temperature{5}`

a temperature of 5 K

`\amount{<magnitude>}`

Command for amount.

an amount of `\amount{5}`

an amount of 5 mol

`\luminous{<magnitude>}`

Command for luminous intensity.

a luminous intensity of `\luminous{5}`

a luminous intensity of 5 cd

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

`\planeangle{<magnitude>}`

Command for plane angle in radians.

a plane angle of `\planeangle{5}`

a plane angle of $5 \text{ m} \cdot \text{m}^{-1}$

`\solidangle{<magnitude>}`

Command for solid angle.

a solid angle of `\solidangle{5}`

a solid angle of $5 \text{ m}^2 \cdot \text{m}^{-2}$

`\indegrees{<magnitude>}`

Command for plane angle in degrees.

a plane angle of `\indegrees{5}`

a plane angle of 5°

`\inarcminutes{<magnitude>}`

Command for plane angle in minutes of arc.

an angle of `\inarcminutes{5}`

an angle of 5'

`\inarcseconds{<magnitude>}`

Command for plane angle in seconds of arc.

an angle of `\inarcseconds{5}`

an angle of 5''

`\inFahrenheit{<magnitude>}`

Command for temperature in degrees Fahrenheit.

a temperature of `\inFahrenheit{68}`

a temperature of 68°F

`\inCelsius{<magnitude>}`

Command for temperature in degrees Celsius.

a temperature of `\inCelsius{20}`

a temperature of 20°C

`\ineV{<magnitude>}`

Command for energy in electron volts.

an energy of `\ineV{10.2}`

an energy of 10.2 eV

`\ineVocs{<magnitude>}`

Command for mass in eV/c².

a mass of `\ineVocs{1.1}`

a mass of 1.1 eV/c²

`\ineVoc{<magnitude>}`

Command for momentum in eV/c.

a momentum of `\ineVoc{3.6}`

a momentum of 3.6 eV/c

`\inMeV{<magnitude>}`

Command for energy in millions of electron volts.

an energy of `\inMeV{2.2}`

an energy of 2.2 MeV

`\inMeVocs{<magnitude>}`

Command for mass in MeV/c².

a mass of `\inMeVocs{0.511}`

a mass of 0.511 MeV/c²

`\inMeVoc{<magnitude>}`

Command for momentum in MeV/c.

a momentum of `\inMeVoc{3.6}`

a momentum of 3.6 MeV/c

`\inGeV{<magnitude>}`

Command for energy in millions of electron volts.

an energy of `\inGeV{2.2}`

an energy of 2.2 GeV

`\inGeVocs{<magnitude>}`

Command for mass in GeV/c².

a mass of `\inGeVocs{0.511}`

a mass of 0.511 GeV/c²

`\inGeVoc{<magnitude>}`

Command for momentum in GeV/c.

a momentum of `\inGeVoc{3.6}`

a momentum of 3.6 GeV/c

`\inamu{<magnitude>}`

Command for mass in atomic mass units.

an atomic mass of `\inamu{4.002602}`

an atomic mass of 4.002602 u

`\inAU{<magnitude>}`

Command for displacement in astronomical units.

a semimajor axis of `\inAU{5.2}`

a semimajor axis of 5.2 AU

`\inly{<magnitude>}`

Command for displacement in light years.

a distance of `\inly{4.3}`

a distance of 4.3 ly

`\incyr{<magnitude>}`

Command for displacement in light years written differently.

a distance of `\incyr{4.3}`

a distance of 4.3 c · year

`\inpc{<magnitude>}`

Command for displacement in parsecs.

a distance of `\inpc{4.3}`

a distance of 4.3 pc

`\insolarL{<magnitude>}`

Command for luminosity in solar multiples.

a luminosity of `\insolarL{4.3}`

a luminosity of $4.3 L_{\odot}$

`\insolarT{<magnitude>}`

Command for temperature in solar multiples.

a temperature of `\insolarT{2}`

a temperature of $2 T_{\odot}$

`\insolarR{<magnitude>}`

Command for radius in solar multiples.

a radius of `\insolarR{4.3}`

a radius of $4.3 R_{\odot}$

`\insolarM{<magnitude>}`

Command for mass in solar multiples.

a mass of `\insolarM{4.3}`

a mass of $4.3 M_{\odot}$

`\insolarF{<magnitude>}`

Command for flux in solar multiples.

a flux of `\insolarF{4.3}`

a flux of $4.3 F_{\odot}$

`\insolarf{<magnitude>}`

Command for apparent flux in solar multiples.

an apparent flux of `\insolarf{4.3}`

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

`\insolarMag{<magnitude>}`

Command for absolute magnitude in solar multiples.

an absolute magnitude of `\insolarMag{2}`

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

`\insolarmag{<magnitude>}`

Command for apparent magnitude in solar multiples.

an apparent magnitude of `\insolarmag{2}`

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

`\insolarD{<magnitude>}`

Command for distance in solar multiples.

a distance of `\insolarD{2}`

a distance of $2 D_{\odot}$

`\insolard`{*magnitude*}

Identical to `\insolarD` but uses d .

a distance of `\insolard{2}`

a distance of $2d_{\odot}$

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

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

`\velocityc`{*magnitude or vector*}

Command for velocity as a fraction of c .

a velocity of `\velocityc{0.9987}` \\
a velocity of `\velocityc{\mivector{0,0.9987,0}}` \\
a velocity of $\langle \mivector{\velocityc{\frac{1}{\sqrt{3}}}}, \mivector{\velocityc{\frac{1}{\sqrt{3}}}}, \mivector{\velocityc{\frac{1}{\sqrt{3}}}} \rangle$

a velocity of $0.9987c$
a velocity of $\langle 0, 0.9987, 0 \rangle c$
a velocity of $\langle \frac{1}{\sqrt{3}}c, \frac{1}{\sqrt{3}}c, \frac{1}{\sqrt{3}}c \rangle$

`\velocity`{*magnitude or vector*}

Command for velocity.

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

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

`\speed`{*magnitude*}

Command for speed. Technically, velocity is defined as the quotient of displacement and duration while speed is defined as the quotient of distance traveled and duration. They have the same dimension and unit, but are slightly conceptually different so separate commands are provided. I've never seen speed used as anything other than a scalar, but of course you can specify a vector if you wish.

a speed of `\velocity{8.25}`

a speed of 8.25 m/s

`\lorentz`{*magnitude*}

Command for relativistic Lorentz factor. Obviously this command doesn't do anything visually, but is included for thinking about calculations where this quantity is needed.

a Lorentz factor of `\lorentz{2.34}`

a Lorentz factor of 2.34

`\momentum`{*magnitude or vector*}

Command for momentum.

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

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

`\acceleration`{*magnitude or vector*}

Command for acceleration.

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

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

`\gravitationalfield`{*magnitude or vector*}

Command for gravitational field.

a gravitational field of λ
`\gravitationalfield{2.34}` \\
a gravitational field of λ
`\gravitationalfield{\mivector{3,2,-1}}`

a gravitational field of 2.34 N/kg
a gravitational field of $\langle 3, 2, -1 \rangle \text{ N/kg}$

`\gravitationalpotential`{*magnitude*}

Command for gravitational potential.

a gravitational potential of λ
`\gravitationalpotential{2.34}`

a gravitational potential of 2.34 J/kg

`\impulse`{*magnitude or vector*}

Command for impulse. Impulse and change in momentum are conceptually different and a case can be made for expressing the in different, but equivalent, units.

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

an impulse of $2.34 \text{ N} \cdot \text{s}$
an impulse of $\langle 3, 2, -1 \rangle \text{ N} \cdot \text{s}$

`\force`{*magnitude or vector*}

Command for force.

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

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

`\springstiffness`{*magnitude*}

Command for spring stiffness.

a spring stiffness of `\springstiffness{2.34}`

a spring stiffness of 2.34 N/m

`\springstretch`{*magnitude*}

Command for spring stretch.

a spring stretch of `\springstretch{2.34}`

a spring stretch of 2.34 m

`\area`{*magnitude*}

Command for area.

an area of `\area{2.34}`

an area of 2.34 m²

`\volume{<magnitude>}`

Command for volume.

a volume of `\volume{2.34}`

a volume of 2.34 m³

`\linearmassdensity{<magnitude>}`

Command for linear mass density.

a linear mass density of `\linearmassdensity{2.34}`

a linear mass density of 2.34 kg/m

`\areamassdensity{<magnitude>}`

Command for area mass density.

an area mass density of `\areamassdensity{2.34}`

an area mass density of 2.34 kg/m²

`\volumemassdensity{<magnitude>}`

Command for volume mass density.

a volume mass density of `\volumemassdensity{2.34}`

a volume mass density of 2.34 kg/m³

`\youngsmodulus{<magnitude>}`

Command for Young's modulus.

a Young's modulus of `\youngsmodulus{2.34\timestento{9}}`

a Young's modulus of 2.34 × 10⁹Pa

`\work{<magnitude>}`

Command for work. Energy and work are conceptually different and a case can be made for expressing them in different, but equivalent, units.

an amount of work `\work{2.34}`

an amount of work 2.34 J

`\energy{<magnitude>}`

Command for energy. Work and energy are conceptually different and a case can be made for expressing them in different, but equivalent, units.

an amount of energy `\energy{2.34}`

an amount of energy 2.34 J

`\power{<magnitude>}`

Command for power.

an amount of power `\power{2.34}`

an amount of power 2.34 W

`\specificheatcapacity{<magnitude>}`

Command for specific heat capacity.

a specific heat capacity of \int
`\specificheatcapacity{4.18\xtento{3}}`

a specific heat capacity of $4.18 \times 10^3 \text{ J/K} \cdot \text{kg}$

`\angularvelocity{<magnitude or vector>}`

Command for angular velocity.

an angular velocity of `\angularvelocity{2.34}`

an angular velocity of 2.34 rad/s

`\angularacceleration{<magnitude or vector>}`

Command for angular acceleration.

an angular acceleration of \int
`\angularacceleration{2.34}`

an angular acceleration of 2.34 rad/s^2

`\angularmomentum{<magnitude or vector>}`

Command for angular momentum. Whether or not the units contain radians is determined by whether the **useradians** option was used when `mandi` was loaded.

an angular momentum of `\angularmomentum{2.34}`

an angular momentum of $2.34 \text{ m}^2 \cdot \text{kg} \cdot \text{s}^{-1}$

`\angularimpulse{<magnitude or vector>}`

Command for angular impulse. Whether or not the units contain radians is determined by whether the **useradians** option was used when `mandi` was loaded.

an angular impulse of `\angularimpulse{2.34}`

an angular impulse of $2.34 \text{ J} \cdot \text{s}$

`\torque{<magnitude or vector>}`

Command for torque. Whether or not the units contain radians is determined by whether the **useradians** option was used when `mandi` was loaded.

a torque of `\torque{2.34}`

a torque of 2.34 J

`\momentofinertia{<magnitude>}`

Command for moment of inertia.

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

a moment of inertia of $2.34 \text{ J} \cdot \text{s}^2$

`\entropy{<magnitude>}`

Command for entropy.

an entropy of `\entropy{2.34}`

an entropy of 2.34 J/K

`\wavelength{<magnitude>}`
Command for wavelength.

a wavelength of `\wavelength{4.00\timestento{-7}}`

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

`\wavenumber{<magnitude>}`
Command for wavenumber.

a wavenumber of `\wavenumber{2.50\timestento{6}}`

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

`\frequency{<magnitude>}`
Command for frequency.

a frequency of `\frequency{7.50\timestento{14}}`

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

`\angularfrequency{<magnitude>}`
Command for angularfrequency.

an angular frequency of `\angularfrequency{4.70\timestento{15}}`

an angular frequency of $4.70 \times 10^{15}\text{rad/s}$

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.

5.6 Second Semester Physics

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

5.6.1 Predefined Quantities

`\charge{<magnitude>}`
Command for electric charge.

a charge of `\charge{2\timestento{-9}}`

a charge of $2 \times 10^{-9}\text{C}$

`\permittivity{<magnitude>}`
Command for permittivity.

a permittivity of `\permittivity{9\timestento{-12}}`

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

`\electricdipolemoment{⟨magnitude or vector⟩}`
Command for electric dipole moment.

an electric dipole moment of ϱ
`\electricdipolemoment{2\timestento{5}}`

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

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

a permeability of ϱ
`\permeability{4\pi\timestento{-7}}`

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

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

a magnetic field of `\magneticfield{1.25}`

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

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

a magnetic field of `\cmagneticfield{1.25}`

a magnetic field of 1.25N/C

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

a linear charge density of ϱ
`\linearchargedensity{4.5\timestento{-3}}`

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

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

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

an area charge density of 1.25C/m^2

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

a volume charge density of ϱ
`\volumechargedensity{1.25}`

a volume charge density of 1.25C/m^3

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

a mobility of ϱ
`\areachargedensity{4.5\timestento{-3}}`

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

`\numberdensity{<magnitude>}`

Command for electron number density.

a number density of 2
`\numberdensity{2\timestento{18}}`

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

`\polarizability{<magnitude>}`

Command for polarizability.

a polarizability of 2
`\polarizability{1.96\timestento{-40}}`

a polarizability of $1.96 \times 10^{-40} \text{C} \cdot \text{m}/(\text{N}/\text{C})$

`\electricpotential{<magnitude>}`

Command for electric potential.

an electric potential of `\electricpotential{1.5}`

an electric potential of 1.5 V

`\emf{<magnitude>}`

Command for emf.

an emf of `\emf{1.5}`

an emf of 1.5 V

`\dielectricconstant{<magnitude>}`

Command for dielectric constant.

a dielectric constant of `\dielectricconstant{1.5}`

a dielectric constant of 1.5

`\indexofrefraction{<magnitude>}`

Command for index of refraction.

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

an index of refraction of 1.5

`\relativepermittivity{<magnitude>}`

Command for relative permittivity.

a relative permittivity of 2
`\relativepermittivity{0.9}`

a relative permittivity of 0.9

`\relativepermeability{<magnitude>}`

Command for relative permeability.

a relative permeability of 2
`\relativepermeability{0.9}`

a relative permeability of 0.9

`\energydensity{<magnitude>}`

Command for energy density.

an energy density of `\energydensity{1.25}`

an energy density of 1.25 J/m^3

`\energyflux{<magnitude>}`

Command for energy flux.

an energy flux of `\energyflux{4\timestento{26}}`

an energy flux of $4 \times 10^{26} \text{ W/m}^2$

`\electroncurrent{<magnitude>}`

Command for electron current.

an electron current of λ

`\electroncurrent{2\timestento{18}}`

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

`\conventionalcurrent{<magnitude>}`

Command for conventional current.

a conventional current of λ

`\conventionalcurrent{0.003}`

a conventional current of 0.003 A

`\magneticdipolemoment{<magnitude or vector>}`

Command for magnetic dipole moment.

a magnetic dipole moment of λ

`\magneticdipolemoment{1.25}`

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

`\currentdensity{<magnitude or vector>}`

Command for current density.

a current density of `\currentdensity{1.25}`

a current density of 1.25 A/m^2

`\electricflux{<magnitude>}`

Command for electric flux.

an electric flux of `\electricflux{1.25}`

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

`\magneticflux{<magnitude>}`

Command for magnetic flux.

a magnetic flux of `\magneticflux{1.25}`

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

`\capacitance{<magnitude>}`

Command for capacitance.

a capacitance of `\capacitance{1.00}`

a capacitance of 1.00 C/V

`\inductance{<magnitude>}`
Command for inductance.

an inductance of `\inductance{1.00}`

an inductance of 1.00 V · s/A

`\conductivity{<magnitude>}`
Command for conductivity.

a conductivity of `\conductivity{1.25}`

a conductivity of 1.25 (A/m²)/(V/m)

`\resistivity{<magnitude>}`
Command for resistivity.

a resistivity of `\resistivity{1.25}`

a resistivity of 1.25 (V/m)/(A/m²)

`\resistance{<magnitude>}`
Command for resistance.

a resistance of `\resistance{1\timestento{6}}`

a resistance of 1 × 10⁶Ω

`\conductance{<magnitude>}`
Command for conductance.

a conductance of `\conductance{1\timestento{6}}`

a conductance of 1 × 10⁶S

`\magneticcharge{<magnitude>}`
Command for magnetic charge, in case it actually exists.

a magnetic charge of `\magneticcharge{1.25}`

a magnetic charge of 1.25 m · A

5.7 Further Words on Units

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

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

`\hereusebaseunit{<magnitude>}`
Command for using base units in place.

a momentum of `\hereusebaseunit{\momentum{3}}`

a momentum of 3 m · kg · s⁻¹

`\hereusedrvdunit{<magnitude>}`
Command for using derived units in place.

a momentum of `\hereusedrvdunit{\momentum{3}}`

a momentum of 3 N · s

`\hereusetradunit{<magnitude>}`

Command for using traditional units in place.

a momentum of `\hereusetradunit{\momentum{3}}`

a momentum of 3 kg · m/s

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

`\begin{usebaseunit}`
<environment content>

`\end{usebaseunit}`

Environment for using base units.

`\begin{usebaseunit}`
`\momentum{3}`
`\end{usebaseunit}`

3 m · kg · s⁻¹

`\begin{usedrvdunit}`
<environment content>

`\end{usedrvdunit}`

Environment for using derived units.

`\begin{usedrvdunit}`
`\momentum{3}`
`\end{usedrvdunit}`

3 N · s

`\begin{usetradunit}`
<environment content>

`\end{usetradunit}`

Environment for using traditional units.

`\begin{usetradunit}`
`\momentum{3}`
`\end{usetradunit}`

3 kg · m/s

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

`\perpusebaseunit`

Command for perpetually using base units.

`\perpusedrvdunit`

Command for perpetually using derived units..

`\perpusetradunit`

Command for perpetually using traditional units..

Here are all the predefined quantities and their units.

name <code>\displacement</code>	baseunit m	drvdunit m	tradunit m
name <code>\mass</code>	baseunit kg	drvdunit kg	tradunit kg
name <code>\duration</code>	baseunit s	drvdunit s	tradunit s
name <code>\current</code>	baseunit A	drvdunit A	tradunit A
name <code>\temperature</code>	baseunit K	drvdunit K	tradunit K
name <code>\amount</code>	baseunit mol	drvdunit mol	tradunit mol
name <code>\luminous</code>	baseunit cd	drvdunit cd	tradunit cd
name <code>\planeangle</code>	baseunit $\text{m} \cdot \text{m}^{-1}$	drvdunit rad	tradunit $\text{m} \cdot \text{m}^{-1}$
name <code>\solidangle</code>	baseunit $\text{m}^2 \cdot \text{m}^{-2}$	drvdunit sr	tradunit $\text{m}^2 \cdot \text{m}^{-2}$
name <code>\velocity</code>	baseunit $\text{m} \cdot \text{s}^{-1}$	drvdunit $\text{m} \cdot \text{s}^{-1}$	tradunit m/s
name <code>\acceleration</code>	baseunit $\text{m} \cdot \text{s}^{-2}$	drvdunit N/kg	tradunit m/s^2
name <code>\gravitationalfield</code>	baseunit $\text{m} \cdot \text{s}^{-2}$	drvdunit N/kg	tradunit N/kg
name <code>\gravitationalpotential</code>	baseunit $\text{m}^2 \cdot \text{s}^{-2}$	drvdunit J/kg	tradunit J/kg
name <code>\momentum</code>	baseunit $\text{m} \cdot \text{kg} \cdot \text{s}^{-1}$	drvdunit N · s	tradunit $\text{kg} \cdot \text{m}/\text{s}$
name <code>\impulse</code>	baseunit $\text{m} \cdot \text{kg} \cdot \text{s}^{-1}$	drvdunit N · s	tradunit N · s
name <code>\force</code>	baseunit $\text{m} \cdot \text{kg} \cdot \text{s}^{-2}$	drvdunit N	tradunit N
name <code>\springstiffness</code>	baseunit $\text{kg} \cdot \text{s}^{-2}$	drvdunit N/m	tradunit N/m

name <code>\springstretch</code>	baseunit m	drvdunit m	tradunit m
name <code>\area</code>	baseunit m^2	drvdunit m^2	tradunit m^2
name <code>\volume</code>	baseunit m^3	drvdunit m^3	tradunit m^3
name <code>\linearmassdensity</code>	baseunit $m^{-1} \cdot kg$	drvdunit kg/m	tradunit kg/m
name <code>\areamassdensity</code>	baseunit $m^{-2} \cdot kg$	drvdunit kg/m ²	tradunit kg/m ²
name <code>\volumemassdensity</code>	baseunit $m^{-3} \cdot kg$	drvdunit kg/m ³	tradunit kg/m ³
name <code>\youngsmodulus</code>	baseunit $m^{-1} \cdot kg \cdot s^{-2}$	drvdunit N/m ²	tradunit Pa
name <code>\stress</code>	baseunit $m^{-1} \cdot kg \cdot s^{-2}$	drvdunit N/m ²	tradunit Pa
name <code>\pressure</code>	baseunit $m^{-1} \cdot kg \cdot s^{-2}$	drvdunit N/m ²	tradunit Pa
name <code>\strain</code>	baseunit	drvdunit	tradunit
name <code>\work</code>	baseunit $m^2 \cdot kg \cdot s^{-2}$	drvdunit N · m	tradunit J
name <code>\energy</code>	baseunit $m^2 \cdot kg \cdot s^{-2}$	drvdunit N · m	tradunit J
name <code>\power</code>	baseunit $m^2 \cdot kg \cdot s^{-3}$	drvdunit J/s	tradunit W
name <code>\specificeatcapacity</code>	baseunit J/K · kg	drvdunit J/K · kg	tradunit J/K · kg
name <code>\angularvelocity</code>	baseunit rad · s ⁻¹	drvdunit rad/s	tradunit rad/s
name <code>\angularacceleration</code>	baseunit rad · s ⁻²	drvdunit rad/s ²	tradunit rad/s ²
name <code>\momentofinertia</code>	baseunit $m^2 \cdot kg$	drvdunit $m \cdot kg^2$	tradunit $J \cdot s^2$
name <code>\angularmomentum</code>	baseunit $m^2 \cdot kg \cdot s^{-1}$	drvdunit N · m · s	tradunit $m^2 \cdot kg \cdot s^{-1}$

<code>\angularimpulse</code>	name baseunit $\text{m}^2 \cdot \text{kg} \cdot \text{s}^{-1}$	drvdunit $\text{N} \cdot \text{m} \cdot \text{s}$	tradunit $\text{J} \cdot \text{s}$
<code>\torque</code>	name baseunit $\text{m}^2 \cdot \text{kg} \cdot \text{s}^{-2}$	drvdunit $\text{N} \cdot \text{m}$	tradunit J
<code>\entropy</code>	name baseunit $\text{m}^2 \cdot \text{kg} \cdot \text{s}^{-2} \cdot \text{K}^{-1}$	drvdunit J/K	tradunit J/K
<code>\wavelength</code>	name baseunit m	drvdunit m	tradunit m
<code>\wavenumber</code>	name baseunit m^{-1}	drvdunit $/\text{m}$	tradunit $/\text{m}$
<code>\frequency</code>	name baseunit s^{-1}	drvdunit Hz	tradunit Hz
<code>\angularfrequency</code>	name baseunit $\text{rad} \cdot \text{s}^{-1}$	drvdunit rad/s	tradunit rad/s
<code>\charge</code>	name baseunit $\text{A} \cdot \text{s}$	drvdunit C	tradunit C
<code>\permittivity</code>	name baseunit $\text{m}^{-3} \cdot \text{kg}^{-1} \cdot \text{s}^{-4} \cdot \text{A}^2$	drvdunit F/m	tradunit $\text{C}^2/\text{N} \cdot \text{m}^2$
<code>\permeability</code>	name baseunit $\text{m} \cdot \text{kg} \cdot \text{s}^{-2} \cdot \text{A}^{-2}$	drvdunit H/m	tradunit $\text{T} \cdot \text{m}/\text{A}$
<code>\electricfield</code>	name baseunit $\text{m} \cdot \text{kg} \cdot \text{s}^{-3} \cdot \text{A}^{-1}$	drvdunit V/m	tradunit N/C
<code>\electricdipolemoment</code>	name baseunit $\text{m} \cdot \text{s} \cdot \text{A}$	drvdunit $\text{C} \cdot \text{m}$	tradunit $\text{C} \cdot \text{m}$
<code>\electricflux</code>	name baseunit $\text{m}^3 \cdot \text{kg} \cdot \text{s}^{-3} \cdot \text{A}^{-1}$	drvdunit $\text{V} \cdot \text{m}$	tradunit $\text{N} \cdot \text{m}^2/\text{C}$
<code>\magneticfield</code>	name baseunit $\text{kg} \cdot \text{s}^{-2} \cdot \text{A}^{-1}$	drvdunit T	tradunit $\text{N}/\text{C} \cdot (\text{m}/\text{s})$
<code>\magneticflux</code>	name baseunit $\text{m}^2 \cdot \text{kg} \cdot \text{s}^{-2} \cdot \text{A}^{-1}$	drvdunit $\text{V} \cdot \text{s}$	tradunit $\text{T} \cdot \text{m}^2$
<code>\cmagneticfield</code>	name baseunit $\text{m} \cdot \text{kg} \cdot \text{s}^{-3} \cdot \text{A}^{-1}$	drvdunit V/m	tradunit N/C
<code>\linearchargedensity</code>	name baseunit $\text{m}^{-1} \cdot \text{s} \cdot \text{A}$	drvdunit C/m	tradunit C/m
<code>\areachargedensity</code>	name baseunit $\text{m}^{-2} \cdot \text{s} \cdot \text{A}$	drvdunit C/m^2	tradunit C/m^2

<code>\volumechargedensity</code>	name baseunit $m^{-3} \cdot s \cdot A$	drvdunit C/m^3	tradunit C/m^3
<code>\mobility</code>	name baseunit $m^2 \cdot kg \cdot s^{-4} \cdot A^{-1}$	drvdunit $m^2/V \cdot s$	tradunit $(m/s)/(N/C)$
<code>\numberdensity</code>	name baseunit m^{-3}	drvdunit $/m^3$	tradunit $/m^3$
<code>\polarizability</code>	name baseunit $kg^{-1} \cdot s^4 \cdot A^2$	drvdunit $C \cdot m^2/V$	tradunit $C \cdot m/(N/C)$
<code>\electricpotential</code>	name baseunit $m^2 \cdot kg \cdot s^{-3} \cdot A^{-1}$	drvdunit J/C	tradunit V
<code>\emf</code>	name baseunit $m^2 \cdot kg \cdot s^{-3} \cdot A^{-1}$	drvdunit J/C	tradunit V
<code>\dielectricconstant</code>	name baseunit	drvdunit	tradunit
<code>\indexofrefraction</code>	name baseunit	drvdunit	tradunit
<code>\relativepermittivity</code>	name baseunit	drvdunit	tradunit
<code>\relativepermeability</code>	name baseunit	drvdunit	tradunit
<code>\energydensity</code>	name baseunit $m^{-1} \cdot kg \cdot s^{-2}$	drvdunit J/m^3	tradunit J/m^3
<code>\energyflux</code>	name baseunit $kg \cdot s^{-3}$	drvdunit W/m^2	tradunit W/m^2
<code>\electroncurrent</code>	name baseunit s^{-1}	drvdunit e/s	tradunit e/s
<code>\conventionalcurrent</code>	name baseunit A	drvdunit C/s	tradunit A
<code>\magneticdipolemoment</code>	name baseunit $m^2 \cdot A$	drvdunit J/T	tradunit $A \cdot m^2$
<code>\currentdensity</code>	name baseunit $m^{-2} \cdot A$	drvdunit $C \cdot s/m^2$	tradunit A/m^2
<code>\capacitance</code>	name baseunit $m^{-2} \cdot kg^{-1} \cdot s^4 \cdot A^2$	drvdunit F	tradunit C/V
<code>\inductance</code>	name baseunit $m^2 \cdot kg \cdot s^{-2} \cdot A^{-2}$	drvdunit H	tradunit $V \cdot s/A$

name <code>\conductivity</code>	baseunit $m^{-3} \cdot kg^{-1} \cdot s^3 \cdot A^2$	drvdunit S/m	tradunit $(A/m^2)/(V/m)$
name <code>\resistivity</code>	baseunit $m^3 \cdot kg \cdot s^{-3} \cdot A^{-2}$	drvdunit $\Omega \cdot m$	tradunit $(V/m)/(A/m^2)$
name <code>\resistance</code>	baseunit $m^2 \cdot kg \cdot s^{-3} \cdot A^{-2}$	drvdunit V/A	tradunit Ω
name <code>\conductance</code>	baseunit $m^{-2} \cdot kg^{-1} \cdot s^3 \cdot A^2$	drvdunit A/V	tradunit S
name <code>\magneticcharge</code>	baseunit $m \cdot A$	drvdunit $m \cdot A$	tradunit $m \cdot A$

5.8 Symbolic Expressions with Vectors

5.8.1 Basic Vectors

`\vect{<kernel>}`

Symbol for a vector quantity.

`\vect{p}`

\vec{p}

`\magvect{<kernel>}`

Symbol for magnitude of a vector quantity.

`\magvect{p}`

$\|\vec{p}\|$

`\magsquaredvect{<kernel>}`

Symbol for squared magnitude of a vector quantity.

`\magsquaredvect{p}`

$\|\vec{p}\|^2$

`\magnvect{<kernel>}{<exponent>}`

Symbol for magnitude of a vector quantity to arbitrary power.

`\magnvect{r}{5}`

$\|\vec{r}\|^5$

`\dirvect{<kernel>}`

Symbol for direction of a vector quantity. Use `\direction` as an alias.

`\dirvect{p}` or `\direction{p}`

\hat{p} or \hat{p}

`\componentalong{<alongvector>}{<ofvector>}`

Symbol for the component along a vector of another vector.

`\componentalong{\vect{v}}{\vect{u}}`

$\text{comp}_{\vec{v}} \vec{u}$

`\expcomponentalong{<alongvector>}{<ofvector>}`

Symbolic expression for the component along a vector of another vector.

`\expcomponentalong{\vect{v}}{\vect{u}}`

$\frac{\vec{u} \cdot \vec{v}}{\|\vec{v}\|}$

`\ucomponentalong{<alongvector>}{<ofvector>}`

Symbolic expression with unit vectors for the component along a vector of another vector.

`\ucomponentalong{\dirvect{v}}{\vect{u}}`

$\vec{u} \cdot \hat{v}$

`\projectiononto{<ontovector>}{<ofvector>}`

Symbol for the projection onto a vector of another vector.

`\projectiononto{\vect{v}}{\vect{u}}`

$\text{proj}_{\vec{v}} \vec{u}$

`\expprojectiononto{<alongvector>}{<ofvector>}`

Symbolic expression for the projection onto a vector of another vector.

`\expprojectiononto{\vect{v}}{\vect{u}}`

$\left(\frac{\vec{u} \cdot \vec{v}}{\|\vec{v}\|^2} \right) \frac{\vec{v}}{\|\vec{v}\|}$

`\uprojectiononto{<alongvector>}{<ofvector>}`

Symbolic expression with unit vectors for the projection onto a vector of another vector.

`\uprojectiononto{\dirvect{v}}{\vect{u}}`

$(\vec{u} \cdot \hat{v}) \hat{v}$

`\mivector[<printeddelimiter>]{<commadelimitedlistofcomps>}[<unit>]`

Generic workhorse command for vectors formatted as in *Matter & Interactions*. Unless the first optional argument is specified, a comma is used in the output. Commas are always required in the mandatory argument.

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

$u_{\mu} = \langle e_0, e_1, e_2, e_3 \rangle$

$u_{\mu} = \langle e_0 \ e_1 \ e_2 \ e_3 \rangle$

$\vec{v} = \langle 1, 3, 5 \rangle \text{ m/s}$

$\vec{E} = \left\langle \frac{1}{4\pi\epsilon_0} \frac{Q}{x^2}, 0, 0 \right\rangle$

$\vec{E} = \left\langle \frac{1}{4\pi\epsilon_0} \frac{Q}{x^2} \ 0 \ 0 \right\rangle$

`\ncompszerovect`

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

`\ncompszerovect`

$\langle 0, 0, 0 \rangle$

`\magvectncomps{<listofcomps>}[<unit>]`

Expression for a vector's magnitude with numerical components and an optional unit. The first example is the preferred and recommended way to handle units when they are needed. The second example requires explicitly picking out the desired unit form. The third example demonstrates components of a unit vector. It is probably best for students to include components' units inside the radical than to write them outside the radical.

```
\magvectncomps{\velocity{3.12},\velocity{4.04},\velocity{6.73}} \\  
\magvectncomps{3.12,4.04,6.73}[\velocityonlytradunit] \\  
\magvectncomps{\frac{1}{\sqrt{3}},\frac{1}{\sqrt{3}},\frac{1}{\sqrt{3}}}
```

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

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

$$\sqrt{\left(\frac{1}{\sqrt{3}}\right)^2 + \left(\frac{1}{\sqrt{3}}\right)^2 + \left(\frac{1}{\sqrt{3}}\right)^2}$$

\scompsvect{*kernel*}

Expression for a vector's symbolic components.

<code>\scompsvect{E}</code>	$\langle E_x, E_y, E_z \rangle$
-----------------------------	---------------------------------

\compvect{*kernel*}{*component*}

Isolates one of a vector's symbolic components.

<code>\compvect{E}{y}</code>	E_y
------------------------------	-------

\scompsdirvect{*kernel*}

Expression for a direction's symbolic components.

<code>\scompsdirvect{r}</code>	$\langle \hat{r}_x, \hat{r}_y, \hat{r}_z \rangle$
--------------------------------	---

\compdirvect{*kernel*}{*component*}

Isolates one of a direction's symbolic components.

<code>\compdirvect{r}{z}</code>	\hat{r}_z
---------------------------------	-------------

\magvectscomps{*kernel*}

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

<code>\magvectscomps{B}</code>	$\sqrt{B_x^2 + B_y^2 + B_z^2}$
--------------------------------	--------------------------------

5.8.2 Differentials and Derivatives of Vectors

\dvect{*kernel*}

Symbol for the differential of a vector.

a change <code>\dvect{E}</code> in electric field	a change $d\vec{E}$ in electric field
---	---------------------------------------

\Dvect{*kernel*}

Identical to `\dvect` but uses Δ .

a change $\backslash\text{dvect}\{E\}$ in electric field

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

$\backslash\text{dirvect}\{\langle kernel \rangle\}$

Symbol for the direction of a vector's differential.

the direction $\backslash\text{dirvect}\{E\}$ of the change

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

$\backslash\text{dirDvect}\{\langle kernel \rangle\}$

Identical to $\backslash\text{dirvect}$ but uses Δ .

the direction $\backslash\text{dirDvect}\{E\}$ of the change

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

$\backslash\text{ddirvect}\{\langle kernel \rangle\}$

Symbol for the differential of a vector's direction. Use $\backslash\text{ddirection}$ as an alias.

the change $\backslash\text{ddirvect}\{E\}$ or $\backslash\text{ddirection}\{E\}$ in \mathcal{D}
(the direction of $\backslash\text{vect}\{E\}$)

the change $d\widehat{E}$ or $d\widehat{E}$ in the direction of \vec{E}

$\backslash\text{Ddirvect}\{\langle kernel \rangle\}$

Identical to $\backslash\text{ddirvect}$ but uses Δ . Use $\backslash\text{Ddirection}$ as an alias.

the direction $\backslash\text{Ddirvect}\{E\}$ or $\backslash\text{Ddirection}\{E\}$ of \mathcal{D}
(the change

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

$\backslash\text{magdvect}\{\langle kernel \rangle\}$

Symbol for the magnitude of a vector's differential.

the magnitude $\backslash\text{magdvect}\{E\}$ of the change

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

$\backslash\text{magDvect}\{\langle kernel \rangle\}$

Identical to $\backslash\text{magdvect}$ but uses Δ .

the magnitude $\backslash\text{magDvect}\{E\}$ of the change

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

$\backslash\text{dmagvect}\{\langle kernel \rangle\}$

Symbol for the differential of a vector's magnitude.

the change $\backslash\text{dmagvect}\{E\}$ in the magnitude

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

$\backslash\text{Dmagvect}\{\langle kernel \rangle\}$

Identical to $\backslash\text{dmagvect}$ but uses Δ .

the change $\backslash\text{Dmagvect}\{E\}$ in the magnitude

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

`\scompsdvect{<kernel>}`

Symbolic components of a vector.

the vector `\scompsdvect{E}`

the vector $\langle dE_x, dE_y, dE_z \rangle$

`\scompsDvect{<kernel>}`

Identical to `\scompsdvect` but uses Δ .

the vector `\scompsDvect{E}`

the vector $\langle \Delta E_x, \Delta E_y, \Delta E_z \rangle$

`\compdvect{<kernel>}{<component>}`

Isolates one symbolic component of a vector's differential.

the `\compdvect{E}{y}` component of the change

the dE_y component of the change

`\compDvect{<kernel>}{<component>}`

Identical to `\compdvect` but uses Δ .

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

the ΔE_y component of the change

`\derivect{<kernel>}{<indvar>}`

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

the derivative `\derivect{E}{t}`

the derivative $\frac{d\vec{E}}{dt}$

`\Dervect{<kernel>}{<indvar>}`

Identical to `\derivect` but uses Δ .

the derivative `\Dervect{E}{t}`

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

`\dermagvect{<kernel>}{<indvar>}`

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

the derivative `\dermagvect{E}{t}`

the derivative $\frac{d\|\vec{E}\|}{dt}$

`\Dermagvect{<kernel>}{<indvar>}`

Identical to `\dermagvect` but uses Δ .

the derivative `\Dermagvect{E}{t}`

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

`\derdirvect{<kernel>}{<indvar>}`

Symbol for the derivative of a vector's direction with respect to an independent variable. Use `\derdiraction` as an alias.

the derivative `\derdirvect{E}{t}` or `\derdirection{E}{t}`

the derivative $\frac{d\hat{E}}{dt}$ or $\frac{d\hat{E}}{dt}$

`\Derdirvect{<kernel>}{<indvar>}`

Identical to `\derdirvect` but uses Δ . Use `\Derdirection` as an alias.

the derivative `\Derdirvect{E}{t}` or `\Derdirection{E}{t}`

the derivative $\frac{\Delta\hat{E}}{\Delta t}$ or $\frac{\Delta\hat{E}}{\Delta t}$

`\scompsdervect{<kernel>}{<indvar>}`

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

the derivative `\scompsdervect{E}{t}`

the derivative $\left\langle \frac{dE_x}{dt}, \frac{dE_y}{dt}, \frac{dE_z}{dt} \right\rangle$

`\scompsDervect{<kernel>}{<indvar>}`

Identical to `\scompsdervect` but uses Δ .

the derivative `\scompsdervect{E}{t}`

the derivative $\left\langle \frac{dE_x}{dt}, \frac{dE_y}{dt}, \frac{dE_z}{dt} \right\rangle$

`\compdervect{<kernel>}{<component>}{<indvar>}`

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

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

the derivative $\frac{dE_y}{dt}$

`\compDervect{<kernel>}{<component>}{<indvar>}`

Identical to `\compdervect` but uses Δ .

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

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

`\magdervect{<kernel>}{<indvar>}`

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

the derivative `\magdervect{E}{t}`

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

`\magDervect{<kernel>}{<indvar>}`

Identical to `\magdervect` but uses Δ .

the derivative `\magDervect{E}{t}`

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

5.8.3 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.

5.8.4 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`. 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.

As a matter of convention, when the initial and final values of a quantity are referenced, they should be labeled with subscripts `i` and `f` respectively using the commands in this section and similarly named commands in other sections. If the quantity also refers to a particular entity (e.g. a ball), specify the `i` or `f` with a comma after the label (e.g. `\vectsub{r}{ball,f}`).

`\vectsub{<kernel>}{<sub>}`

Symbol for a subscripted vector.

the vector `\vectsub{p}{ball}`

the vector \vec{p}_{ball}

`\magvectsub{<kernel>}{<sub>}`

Symbol for a subscripted vector's magnitude.

`\magvectsub{p}{ball}`

$\|\vec{p}_{\text{ball}}\|$

`\magsquaredvectsub{<kernel>}{<sub>}`

Symbol for a subscripted vector's squared magnitude.

`\magsquaredvectsub{p}{ball}`

$\|\vec{p}_{\text{ball}}\|^2$

`\magnvectsub{<kernel>}{<sub>}{<exponent>}`

Symbol for a subscripted vector's magnitude to an arbitrary power.

`\magnvectsub{r}{dipole}{5}`

$\|\vec{r}_{\text{dipole}}\|^5$

`\dirvectsub{<kernel>}{<sub>}`

Symbol for a subscripted vector's direction. Use `\directionsub` as an alias.

`\dirvectsub{p}{ball}` or `\directionsub{p}{ball}`

\hat{p}_{ball} or \hat{p}_{ball}

`\scompsvectsub{<kernel>}{<sub>}`

Symbolic components of a subscripted vector.

the vector `\scompsvectsub{p}{ball}`

the vector $\langle p_{\text{ball},x}, p_{\text{ball},y}, p_{\text{ball},z} \rangle$

`\compvectsub{<kernel>}{<sub>}{<component>}`

Isolates one component of a subscripted vector.

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

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

`\magvectsubcomps{<kernel>}{<sub>}`

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

the magnitude `\magvectsubcomps{p}{ball}`

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

`\dvectsub{<kernel>}{<sub>}`

Differential of a subscripted vector.

the change `\dvectsub{p}{ball}`

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

`\Dvectsub{<kernel>}{<sub>}`

Identical to `\dvectsub` but uses Δ .

the change `\Dvectsub{p}{ball}`

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

`\scompsdvectsub{<kernel>}{<sub>}`

Symbolic components of a subscripted vector's differential.

the vector `\scompsdvectsub{p}{ball}`

the vector $\langle dp_{\text{ball},x}, dp_{\text{ball},y}, dp_{\text{ball},z} \rangle$

`\scompsDvectsub{<kernel>}{<sub>}`

Identical to `\scompsdvectsub` but uses Δ .

the vector `\scompsDvectsub{p}{ball}`

the vector $\langle \Delta p_{\text{ball},x}, \Delta p_{\text{ball},y}, \Delta p_{\text{ball},z} \rangle$

`\compdvectsub{<kernel>}{<sub>}{<component>}`

Isolates one component of a subscripted vector's differential.

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

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

`\compDvectsub{<kernel>}{<sub>}{<component>}`

Identical to `\compdvectsub` but uses Δ .

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

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

`\derivectsub{<kernel>}{<sub>}{<indvar>}`

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

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

the derivative $\frac{d\vec{p}_{\text{ball}}}{dt}$

`\Dervectsub{<kernel>}{<sub>}{<indvar>}`
 Identical to `\dervectsub` but uses Δ .

the derivative <code>\Dervectsub{p}{ball}{t}</code>	the derivative $\frac{\Delta \vec{p}_{\text{ball}}}{\Delta t}$
---	--

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

the derivative <code>\dermagvectsub{E}{ball}{t}</code>	the derivative $\frac{d\ \vec{E}_{\text{ball}}\ }{dt}$
--	--

`\Dermagvectsub{<kernel>}{<sub>}{<indvar>}`
 Identical to `\dermagvectsub` but uses Δ .

the derivative <code>\Dermagvectsub{E}{ball}{t}</code>	the derivative $\frac{\Delta\ \vec{E}_{\text{ball}}\ }{\Delta t}$
--	---

`\scompsdervectsub{<kernel>}{<sub>}{<indvar>}`
 Symbolic components of a subscripted vector's derivative with respect to an independent variable.

the vector <code>\scompsdervectsub{p}{ball}{t}</code>	the vector $\left\langle \frac{dp_{\text{ball},x}}{dt}, \frac{dp_{\text{ball},y}}{dt}, \frac{dp_{\text{ball},z}}{dt} \right\rangle$
---	---

`\scompsDervectsub{<kernel>}{<sub>}{<indvar>}`
 Identical to `\scompsdervectsub` but uses Δ .

the vector <code>\scompsDervectsub{p}{ball}{t}</code>	the vector $\left\langle \frac{\Delta p_{\text{ball},x}}{\Delta t}, \frac{\Delta p_{\text{ball},y}}{\Delta t}, \frac{\Delta p_{\text{ball},z}}{\Delta t} \right\rangle$
---	---

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

the component <code>\compdervectsub{p}{ball}{y}{t}</code>	the component $\frac{dp_{\text{ball},y}}{dt}$
---	---

`\compDervectsub{<kernel>}{<sub>}{<component>}{<indvar>}`
 Identical to `\compdervectsub` but uses Δ .

the component <code>\compDervectsub{p}{ball}{y}{t}</code>	the component $\frac{\Delta p_{\text{ball},y}}{\Delta t}$
---	---

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

the derivative <code>\magdervectsub{p}{ball}{t}</code>	the derivative $\left\ \frac{d\vec{p}_{\text{ball}}}{dt} \right\ $
--	---

`\magDervectsub{<kernel>}{<sub>}{<indvar>}`
 Identical to `\magdervectsub` but uses Δ .

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

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

5.8.5 Expressions Containing Dots

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

`\vectdotvect{<kernel1>}{<kernel2>}`

Symbol for dot of two vectors as a single symbol.

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

$\vec{F} \bullet \vec{v}$

`\vectdotsvect{<kernel1>}{<kernel2>}`

Symbol for dot of two vectors with symbolic components.

`\vectdotsvect{F}{v}`

$\langle F_x, F_y, F_z \rangle \bullet \langle v_x, v_y, v_z \rangle$

`\vectdotevect{<kernel1>}{<kernel2>}`

Symbol for dot of two vectors as an expanded sum.

`\vectdotevect{F}{v}`

$F_x v_x + F_y v_y + F_z v_z$

`\vectdotsdvect{<kernel1>}{<kernel2>}`

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

`\vectdotsdvect{F}{r}`

$\langle F_x, F_y, F_z \rangle \bullet \langle dr_x, dr_y, dr_z \rangle$

`\vectdotsDvect{<kernel1>}{<kernel2>}`

Identical to `\vectdotsdvect` but uses Δ .

`\vectdotsDvect{F}{r}`

$\langle F_x, F_y, F_z \rangle \bullet \langle \Delta r_x, \Delta r_y, \Delta r_z \rangle$

`\vectdotedvect{<kernel1>}{<kernel2>}`

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

`\vectdotedvect{F}{r}`

$F_x dr_x + F_y dr_y + F_z dr_z$

`\vectdoteDvect{<kernel1>}{<kernel2>}`

Identical to `\vectdotedvect` but uses Δ .

$\backslash\text{vectdoteDvect}\{F\}\{r\}$

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

 $\backslash\text{vectsubdotsvectsub}\{\langle\text{kernel1}\rangle\}\{\langle\text{sub1}\rangle\}\{\langle\text{kernel2}\rangle\}\{\langle\text{sub2}\rangle\}$

Dot of two subscripted vectors with symbolic components.

 $\backslash\text{vectsubdotsvectsub}\{F\}\{\text{grav}\}\{r\}\{\text{ball}\}$

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

 $\backslash\text{vectsubdotevectsub}\{\langle\text{kernel1}\rangle\}\{\langle\text{sub1}\rangle\}\{\langle\text{kernel2}\rangle\}\{\langle\text{sub2}\rangle\}$

Dot of two subscripted vectors as an expanded sum.

 $\backslash\text{vectsubdotevectsub}\{F\}\{\text{grav}\}\{r\}\{\text{ball}\}$

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

 $\backslash\text{vectsubdotsdvectsub}\{\langle\text{kernel1}\rangle\}\{\langle\text{sub1}\rangle\}\{\langle\text{kernel2}\rangle\}\{\langle\text{sub2}\rangle\}$

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

 $\backslash\text{vectsubdotsdvectsub}\{A\}\{\text{ball}\}\{B\}\{\text{car}\}$

$$\langle A_{\text{ball},x}, A_{\text{ball},y}, A_{\text{ball},z} \rangle \bullet \langle dB_{\text{car},x}, dB_{\text{car},y}, dB_{\text{car},z} \rangle$$

 $\backslash\text{vectsubdotsDvectsub}\{\langle\text{kernel1}\rangle\}\{\langle\text{sub1}\rangle\}\{\langle\text{kernel2}\rangle\}\{\langle\text{sub2}\rangle\}$ Identical to $\backslash\text{vectsubdotsdvectsub}$ but uses Δ . $\backslash\text{vectsubdotsDvectsub}\{A\}\{\text{ball}\}\{B\}\{\text{car}\}$

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

 $\backslash\text{vectsubdotedvectsub}\{\langle\text{kernel1}\rangle\}\{\langle\text{sub1}\rangle\}\{\langle\text{kernel2}\rangle\}\{\langle\text{sub2}\rangle\}$

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

 $\backslash\text{vectsubdotedvectsub}\{A\}\{\text{ball}\}\{B\}\{\text{car}\}$

$$A_{\text{ball},x} dB_{\text{car},x} + A_{\text{ball},y} dB_{\text{car},y} + A_{\text{ball},z} dB_{\text{car},z}$$

 $\backslash\text{vectsubdoteDvectsub}\{\langle\text{kernel1}\rangle\}\{\langle\text{sub1}\rangle\}\{\langle\text{kernel2}\rangle\}\{\langle\text{sub2}\rangle\}$ Identical to $\backslash\text{vectsubdotedvectsub}$ but uses Δ . $\backslash\text{vectsubdoteDvectsub}\{A\}\{\text{ball}\}\{B\}\{\text{car}\}$

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

 $\backslash\text{vectsubdotsdvect}\{\langle\text{kernel1}\rangle\}\{\langle\text{sub1}\rangle\}\{\langle\text{kernel2}\rangle\}$

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

 $\backslash\text{vectsubdotsdvect}\{A\}\{\text{ball}\}\{B\}$

$$\langle A_{\text{ball},x}, A_{\text{ball},y}, A_{\text{ball},z} \rangle \bullet \langle dB_x, dB_y, dB_z \rangle$$

 $\backslash\text{vectsubdotsDvect}\{\langle\text{kernel1}\rangle\}\{\langle\text{sub1}\rangle\}\{\langle\text{kernel2}\rangle\}$ Identical to $\backslash\text{vectsubdotsdvect}$ but uses Δ . $\backslash\text{vectsubdotsDvect}\{A\}\{\text{ball}\}\{B\}$

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

 $\backslash\text{vectsubdotedvect}\{\langle\text{kernel1}\rangle\}\{\langle\text{sub1}\rangle\}\{\langle\text{kernel2}\rangle\}$

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

`\vectsubdotedvect{A}{ball}{B}`

$$A_{\text{ball},x}dB_x + A_{\text{ball},y}dB_y + A_{\text{ball},z}dB_z$$

`\vectsubdoteDvect{<kernel1>}{<sub1>}{<kernel2>}`

Identical to `\vectsubdotedvect` but uses Δ .

`\vectsubdoteDvect{A}{ball}{B}`

$$A_{\text{ball},x}\Delta B_x + A_{\text{ball},y}\Delta B_y + A_{\text{ball},z}\Delta B_z$$

`\dervectdotsvect{<kernel1>}{<indvar>}{<kernel2>}`

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

`\dervectdotsvect{A}{t}{B}`

$$\left\langle \frac{dA_x}{dt}, \frac{dA_y}{dt}, \frac{dA_z}{dt} \right\rangle \bullet \langle B_x, B_y, B_z \rangle$$

`\Dervectdotsvect{<kernel1>}{<indvar>}{<kernel2>}`

Identical to `\dervectdotsvect` but uses Δ .

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

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

`\dervectdotevect{<kernel1>}{<indvar>}{<kernel2>}`

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

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

$$\frac{dA_x}{dt} B_x + \frac{dA_y}{dt} B_y + \frac{dA_z}{dt} B_z$$

`\Dervectdotevect{<kernel1>}{<indvar>}{<kernel2>}`

Identical to `\dervectdotevect` but uses Δ .

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

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

`\vectdotsdervect{<kernel1>}{<kernel2>}{<indvar>}`

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

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

$$\langle A_x, A_y, A_z \rangle \bullet \left\langle \frac{dB_x}{dt}, \frac{dB_y}{dt}, \frac{dB_z}{dt} \right\rangle$$

`\vectdotsDervect{<kernel1>}{<kernel2>}{<indvar>}`

Identical to `\vectdotsdervect` but uses Δ .

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

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

`\vectdotedervect{<kernel1>}{<kernel2>}{<indvar>}`

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

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

$$A_x \frac{dB_x}{dt} + A_y \frac{dB_y}{dt} + A_z \frac{dB_z}{dt}$$

`\vectdoteDervect{<kernel1>}{<kernel2>}{<indvar>}`
 Identical to `\vectdotedervect` but uses Δ .

`\vectdoteDervect{A}{B}{t}`

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

`\dervectdotsdvect{<kernel1>}{<indvar>}{<kernel2>}`

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

`\dervectdotsdvect{A}{t}{B}`

$$\left\langle \frac{dA_x}{dt}, \frac{dA_y}{dt}, \frac{dA_z}{dt} \right\rangle \bullet \langle dB_x, dB_y, dB_z \rangle$$

`\DervectdotsDvect{<kernel1>}{<indvar>}{<kernel2>}`

Identical to `\dervectdotsdvect` but uses Δ .

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

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

`\dervectdotedvect{<kernel1>}{<indvar>}{<kernel2>}`

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

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

$$\frac{dA_x}{dt} dB_x + \frac{dA_y}{dt} dB_y + \frac{dA_z}{dt} dB_z$$

`\DervectdoteDvect{<kernel1>}{<indvar>}{<kernel2>}`

Identical to `\dervectdotedvect` but uses Δ .

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

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

5.8.6 Expressions Containing Crosses

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

`\vectcrossvect{<kernel1>}{<kernel2>}`

Cross of two vectors.

`\vectcrossvect{\vect{r}}{\vect{p}}`

$$\vec{r} \times \vec{p}$$

`\ltriplecross{<kernel1>}{<kernel2>}{<kernel3>}`

Symbol for left associated triple cross product.

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

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

`\rtriplecross{<kernel1>}{<kernel2>}{<kernel3>}`

Symbol for right associated triple cross product.

`\triplecross{\vect{A}}{\vect{B}}{\vect{C}}`

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

`\ltriplescalar{\langle kernel1 \rangle}{\langle kernel2 \rangle}{\langle kernel3 \rangle}`

Symbol for left associated triple scalar product.

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

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

`\rtriplescalar{\langle kernel1 \rangle}{\langle kernel2 \rangle}{\langle kernel3 \rangle}`

Symbol for right associated triple scalar product.

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

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

5.8.7 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`

$$e_0, e_1, e_2, e_3, e_4$$

`\uezero`

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

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

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

`\ezerozero`

Symbols for basis bivectors with lower indices up to 4.

`\ezerozero, \ezeroone, \ezerotwo, \ezerothree, \ezerofour, up to \efourfour`

$$e_{00}, e_{01}, e_{02}, e_{03}, e_{04}, \text{ up to } e_{44}$$

`\euzero`

Symbols for basis vectors with upper indices up to 4.

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

$$e^0, e^1, e^2, e^3, e^4$$

`\ueuzero`

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

`\ueuzero, \ueuone, \ueutwo, \ueuthree, \ueufour`

$$\hat{e}^0, \hat{e}^1, \hat{e}^2, \hat{e}^3, \hat{e}^4$$

`\euzerozero`

Symbols for basis bivectors with upper indices up to 4.

`\euzerozero, \euzeroone, \euzerotwo, \euzerothree, \euzerofour, up to \eufourfour`

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

`\gzero`

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

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

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

`\guzero`

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

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

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

`\gzerozero`

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

`\gzerozero, \gzeroone, \gzerotwo, \gzerothree, \gzerofour, up to \gfourfour`

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

`\guzerozero`

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

`\guzerozero, \guzeroone, \guzerotwo, \guzerothree, \guzerofour, up to \gufourfour`

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

5.8.8 Other Vector Related

`\colvector{⟨commadelimitedlistofcomps⟩}`

Typesets column vectors.

`\colvector{x^0,x^1,x^2,x^3} \colvector{x_0,x_1,x_2,x_3}`

$\begin{pmatrix} x^0 \\ x^1 \\ x^2 \\ x^3 \end{pmatrix} \begin{pmatrix} x_0 \\ x_1 \\ x_2 \\ x_3 \end{pmatrix}$

`\rowvector{⟨commadelimitedlistofcomps⟩}`

Typesets row vectors.

`\rowvector{x^0,x^1,x^2,x^3} \rowvector{x_0,x_1,x_2,x_3}`

$(x^0 \ x^1 \ x^2 \ x^3) (x_0 \ x_1 \ x_2 \ x_3)$

`\scompsvect[⟨anynonzero⟩]{⟨kernel⟩}`

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

```

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

```

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

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

`\scompscvect` [*any nonzero*] {*kernel*}

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

```

\begin{align*}
\text{\vect{p}} &= \text{\scompsCvect{p}} \ \backslash\backslash
\text{\vect{p}} &= \text{\scompsCvect[4]{p}}
\end{align*}

```

$$\vec{p} = \begin{pmatrix} p^1 \\ p^2 \\ p^3 \end{pmatrix}$$

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

`\scompsrvect` [*any nonzero*] {*kernel*}

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

```

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

```

$$\vec{p} = (p_1 \ p_2 \ p_3)$$

$$\vec{p} = (p_0 \ p_1 \ p_2 \ p_3)$$

`\scompsRvect` [*any nonzero*] {*kernel*}

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

```

\begin{align*}
\text{\vect{p}} &= \text{\scompsRvect{p}} \ \backslash\backslash
\text{\vect{p}} &= \text{\scompsRvect[4]{p}}
\end{align*}

```

$$\vec{p} = (p^1 \ p^2 \ p^3)$$

$$\vec{p} = (p^0 \ p^1 \ p^2 \ p^3)$$

`\bra`{*bra*}

Typesets a Dirac bra.

```

\bra{\Psi^*} or \bra{\frac{1}{a}\Psi^*}

```

$$\langle \Psi^* | \text{ or } \langle \frac{1}{a} \Psi^* |$$

`\ket`{*ket*}

Typesets a Dirac ket.

`\ket{\Psi}` or `\ket{\frac{1}{b}\Psi^*}`

$|\Psi\rangle$ or $|\frac{1}{b}\Psi^*\rangle$

`\bracket{\langle bra\rangle}\{\langle ket\rangle}`

Typesets a Dirac bracket.

`\bracket{\Psi^*}\{\Psi}`

$\langle\Psi^*|\Psi\rangle$

5.9 Physical Constants

5.9.1 Defining Physical Constants

```
\newphysicsconstant{<newname>}  
{<symbol>}  
{\mi@p{<approx>}{<precise>}}  
{<baseunits>}  
[<drvdunits>]  
[<tradunits>]
```

Defines a new physical constant with a name, a symbol, approximate and precise numerical values, required base units, optional derived units, and optional traditional units. The `\mi@p` command is defined internally and is not meant to be otherwise used.

Here is how `\planck` (Planck's constant) is defined internally, showing each part of the definition on a separate line.

```
\newphysicsconstant{planck}  
  {\ensuremath{h}}  
  {\mi@p{6.6}{6.6261}\timestento{-34}}  
  {\m\squared\usk\kg\usk\reciprocal\s}  
  [\J\usk\s]  
  [\J\usk\s]
```

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 approximate or precise numerical value. Note that both values must be present when the constant is defined. By default, precise values are always used but this can be changed when `mandi` is loaded. Note how the values are specified in the definition of the constant.
- 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 `\newnameonlydrvunit` 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.

5.9.2 Predefined Physical Constants

In this section, precise values of constants are used. Approximate values are available as an option when the package is loaded.

`\oofpez`

Coulomb constant.

`\(\oofpezmathsymbol \approx \oofpez\)`

$$\frac{1}{4\pi\epsilon_0} \approx 8.9876 \times 10^9 \text{N} \cdot \text{m}^2/\text{C}^2$$

`\oofpezcs`

Alternate form of Coulomb constant.

`\(\oofpezcsmathsymbol \approx \oofpezcs\)`

$$\frac{1}{4\pi\epsilon_0 c^2} \approx 10^{-7} \text{N} \cdot \text{s}^2/\text{C}^2$$

`\vacuumpermittivity`

Vacuum permittivity.

`\(\vacuumpermittivitymathsymbol \approx \vacuumpermittivity\)`

$$\epsilon_0 \approx 8.8542 \times 10^{-12} \text{C}^2/\text{N} \cdot \text{m}^2$$

`\mzofp`

Biot-Savart constant.

`\(\mzofpmathsymbol \approx \mzofp\)`

$$-\frac{\mu_0}{4\pi} \approx 10^{-7} \text{T} \cdot \text{m}/\text{A}$$

`\vacuumpermeability`

Vacuum permeability.

`\(\vacuumpermeabilitymathsymbol \approx \vacuumpermeability\)`

$$\mu_0 \approx 4\pi \times 10^{-7} \text{T} \cdot \text{m}/\text{A}$$

`\boltzmann`

Boltzmann constant.

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

$$k_B \approx 1.3806 \times 10^{-23} \text{J}/\text{K}$$

`\boltzmannineV`

Alternate form of Boltzmann constant.

`\(\boltzmannineVmathsymbol \approx \boltzmannineV\)`

$$k_B \approx 8.6173 \times 10^{-5} \text{eV}/\text{K}$$

`\stefan`

Stefan-Boltzmann constant.

`\(\stefanboltzmannmathsymbol \approx \stefanboltzmann\)`

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

`\planck`

Planck constant.

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

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

`\planckineV`

Alternate form of Planck constant.

`\(\planckmathsymbol \approx \planckineV\)`

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

`\planckbar`

Reduced Planck constant (Dirac constant).

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

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

`\planckbarineV`

Alternate form of reduced Planck constant (Dirac constant).

`\(\planckbarmathsymbol \approx \planckbarineV\)`

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

`\planckc`

Planck constant times light speed.

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

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

`\planckcineV`

Alternate form of Planck constant times light speed.

`\(\planckcineVmathsymbol \approx \planckcineV\)`

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

`\rydberg`

Rydberg constant.

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

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

`\bohrradius`

Bohr radius.

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

$$a_0 \approx 5.2918 \times 10^{-11} \text{m}$$

`\finestructure`

Fine structure constant.

`\(\finestructuremathsymbol \approx \finestructure\)`

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

`\avogadro`

Avogadro constant.

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

$$N_A \approx 6.0221 \times 10^{23} \text{mol}^{-1}$$

`\universalgrav`

Universal gravitational constant.

`\(\universalgravmathsymbol \approx \universalgrav\)`

$$G \approx 6.6738 \times 10^{-11} \text{N} \cdot \text{m}^2 / \text{kg}^2$$

`\surfacegravfield`

Earth's surface gravitational field strength.

`\(\surfacegravfieldmathsymbol \approx \surfacegravfield\)`

$$g \approx 9.80 \text{N/kg}$$

`\clight`

Magnitude of light's velocity (photon constant).

`\(\clightmathsymbol \approx \clight\)`

$$c \approx 2.9979 \times 10^8 \text{m/s}$$

`\lightinfeet`

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

`\(\lightinfeetmathsymbol \approx \lightinfeet\)`

$$c \approx 0.9836 \text{ft/ns}$$

`\Ratom`

Approximate atomic radius.

`\(\Ratommathsymbol \approx \Ratom\)`

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

`\Mproton`

Proton mass.

`\(\Mprotonmathsymbol \approx \Mproton\)`

$$m_p \approx 1.6726 \times 10^{-27} \text{kg}$$

`\Mneutron`

Neutron mass.

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

$$m_n \approx 1.6749 \times 10^{-27} \text{kg}$$

`\Mhydrogen`

Hydrogen atom mass.

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

$$m_H \approx 1.6737 \times 10^{-27} \text{kg}$$

\Melectron

Electron mass.

<code>\(\Melectronmathsymbol \approx \Melectron\)</code>	$m_e \approx 9.1094 \times 10^{-31}\text{kg}$
--	---

\echarge

Elementary charge quantum.

<code>\(\echargemathsymbol \approx \echarge\)</code>	$e \approx 1.6022 \times 10^{-19}\text{C}$
--	--

\Qelectron

Electron charge.

<code>\(\Qelectronmathsymbol \approx \Qelectron\)</code>	$Q_e \approx -1.6022 \times 10^{-19}\text{C}$
--	---

\qelectron

Alias for \Qelectron.

\Qproton

Proton charge.

<code>\(\Qprotonmathsymbol \approx \Qproton\)</code>	$Q_p \approx +1.6022 \times 10^{-19}\text{C}$
--	---

\qproton

Alias for \Qproton.

\MEarth

Earth's mass.

<code>\(\MEarthmathsymbol \approx \MEarth\)</code>	$M_{\text{Earth}} \approx 5.9736 \times 10^{24}\text{kg}$
--	---

\MMoon

Moon's mass.

<code>\(\MMoonmathsymbol \approx \MMoon\)</code>	$M_{\text{Moon}} \approx 7.3459 \times 10^{22}\text{kg}$
--	--

\MSun

Sun's mass.

<code>\(\MSunmathsymbol \approx \MSun\)</code>	$M_{\text{Sun}} \approx 1.9891 \times 10^{30}\text{kg}$
--	---

\REarth

Earth's radius.

<code>\(\REarthmathsymbol \approx \REarth\)</code>	$R_{\text{Earth}} \approx 6.3675 \times 10^6\text{m}$
--	---

\RMoon

Moon's radius.

`\(\RMoonmathsymbol \approx \RMoon\)`

$$R_{\text{Moon}} \approx 1.7375 \times 10^6 \text{m}$$

`\RSun`

Sun's radius.

`\(\RSunmathsymbol \approx \RSun\)`

$$R_{\text{Sun}} \approx 6.9634 \times 10^8 \text{m}$$

`\ESdist`

Earth-Sun distance.

`\(\ESdistmathsymbol \approx \SEdist\)`

$$\|\vec{r}_{\text{ES}}\| \approx 1.4960 \times 10^{11} \text{m}$$

`\SEdist`

Alias for `\ESdist`.

`\EMdist`

Earth-Moon distance.

`\(\EMdistmathsymbol \approx \EMdist\)`

$$\|\vec{r}_{\text{EM}}\| \approx 3.8440 \times 10^8 \text{m}$$

`\MEdist`

Alias for `\EMdist`.

5.10 Astronomical Constants and Quantities

`\LSun`

Sun's luminosity.

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

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

`\TSun`

Sun's effective temperature.

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

$$T_{\text{Sun}} \approx 5778 \text{K}$$

`\MagSun`

Sun's absolute magnitude.

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

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

`\magSun`

Sun's apparent magnitude.

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

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

`\Lstar[object]`

Symbol for stellar luminosity.

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

L_{\star} or L_{Sirius}

`\Lsolar`

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

`\Lsolar`

L_{\odot}

`\Tstar[object]`

Symbol for stellar temperature.

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

T_{\star} or T_{Sirius}

`\Tsolar`

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

`\Tsolar`

T_{\odot}

`\Rstar[object]`

Symbol for stellar radius.

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

R_{\star} or R_{Sirius}

`\Rsolar`

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

`\Rsolar`

R_{\odot}

`\Mstar[object]`

Symbol for stellar mass.

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

M_{\star} or M_{Sirius}

`\Msolar`

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

`\Msolar`

M_{\odot}

`\Fstar[object]`

Symbol for stellar flux.

`\Fstar` or `\Fstar[Sirius]`

F_{\star} or F_{Sirius}

`\Fsolar`

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

`\Fsolar`

F_{\odot}

`\fstar`

Alias for `\Fstar`.

`\fsolar`

Alias for `\fsolar`.

`\Magstar[<object>]`

Symbol for stellar absolute magnitude.

`\Magstar` or `\Magstar[Sirius]`

M_{\star} or M_{Sirius}

`\Magsolar`

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

`\Magsolar`

M_{\odot}

`\magstar[<object>]`

Symbol for stellar apparent magnitude.

`\magstar` or `\magstar[Sirius]`

m_{\star} or m_{Sirius}

`\magsolar`

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

`\magsolar`

m_{\odot}

`\Dstar[<object>]`

Symbol for stellar distance.

`\Dstar` or `\Dstar[Sirius]`

D_{\star} or D_{Sirius}

`\Dsolar`

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

`\Dsolar`

D_{\odot}

`\dstar`

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

`\dsolar`

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

Here are all the predefined constants and their units.

name	symbol	value	baseunit	drvdunit	tradunit
<code>\oofpez</code>	$\frac{1}{4\pi\epsilon_0}$	8.9876×10^9	$\text{m}^3 \cdot \text{kg} \cdot \text{s}^{-4} \cdot \text{A}^{-2}$	m/F	$\text{N} \cdot \text{m}^2 / \text{C}^2$
<code>\oofpezcs</code>	$\frac{1}{4\pi\epsilon_0 c^2}$	10^{-7}	$\text{m} \cdot \text{kg} \cdot \text{s}^{-2} \cdot \text{A}^{-2}$	$\text{T} \cdot \text{m}^2$	$\text{N} \cdot \text{s}^2 / \text{C}^2$
<code>\vacuumpermittivity</code>	ϵ_0	8.8542×10^{-12}	$\text{m}^{-3} \cdot \text{kg}^{-1} \cdot \text{s}^4 \cdot \text{A}^2$	F/m	$\text{C}^2 / \text{N} \cdot \text{m}^2$
<code>\mzofp</code>	$\frac{\mu_0}{4\pi}$	10^{-7}	$\text{m} \cdot \text{kg} \cdot \text{s}^{-2} \cdot \text{A}^{-2}$	H/m	$\text{T} \cdot \text{m} / \text{A}$
<code>\vacuumpermeability</code>	μ_0	$4\pi \times 10^{-7}$	$\text{m} \cdot \text{kg} \cdot \text{s}^{-2} \cdot \text{A}^{-2}$	H/m	$\text{T} \cdot \text{m} / \text{A}$
<code>\boltzmann</code>	k_B	1.3806×10^{-23}	$\text{m}^2 \cdot \text{kg} \cdot \text{s}^{-2} \cdot \text{K}^{-1}$	J/K	J/K
<code>\boltzmannineV</code>	k_B	8.6173×10^{-5}	$\text{eV} \cdot \text{K}^{-1}$	eV/K	eV/K
<code>\stefanboltzmann</code>	σ	5.6704×10^{-8}	$\text{kg} \cdot \text{s}^{-3} \cdot \text{K}^{-4}$	$\text{W} / \text{m}^2 \cdot \text{K}^4$	$\text{W} / \text{m}^2 \cdot \text{K}^4$
<code>\planck</code>	h	6.6261×10^{-34}	$\text{m}^2 \cdot \text{kg} \cdot \text{s}^{-1}$	J · s	J · s
<code>\planckineV</code>	h	4.1357×10^{-15}	$\text{eV} \cdot \text{s}$	eV · s	eV · s
<code>\planckbar</code>	\hbar	1.0546×10^{-34}	$\text{m}^2 \cdot \text{kg} \cdot \text{s}^{-1}$	J · s	J · s
<code>\planckbarineV</code>	\hbar	6.5821×10^{-16}	$\text{eV} \cdot \text{s}$	eV · s	eV · s
<code>\planckc</code>	hc	1.9864×10^{-25}	$\text{m}^3 \cdot \text{kg} \cdot \text{s}^{-2}$	J · m	J · m
<code>\planckcineV</code>	hc	1.9864×10^{-25}	$\text{eV} \cdot \text{nm}$	eV · nm	eV · nm
<code>\rydberg</code>	R_∞	1.0974×10^7	m^{-1}	m^{-1}	m^{-1}
<code>\bohrradius</code>	a_0	5.2918×10^{-11}	m	m	m
<code>\finestructure</code>	α	7.2974×10^{-3}	baseunit	drvdunit	tradunit

name	symbol	value	baseunit	drvdunit	tradunit
\avogadro	N_A	6.0221×10^{23}	mol^{-1}	mol^{-1}	mol^{-1}
name	symbol	value	baseunit	drvdunit	tradunit
\universalgrav	G	6.6738×10^{-11}	$\text{m}^3 \cdot \text{kg}^{-1} \cdot \text{s}^{-2}$	$\text{J} \cdot \text{m}/\text{kg}^2$	$\text{N} \cdot \text{m}^2/\text{kg}^2$
name	symbol	value	baseunit	drvdunit	tradunit
\surfacegravfield	g	9.80	$\text{m} \cdot \text{s}^{-2}$	N/kg	N/kg
name	symbol	value	baseunit	drvdunit	tradunit
\clight	c	2.9979×10^8	$\text{m} \cdot \text{s}^{-1}$	m/s	m/s
name	symbol	value	baseunit	drvdunit	tradunit
\clightinfeet	c	0.9836	$\text{ft} \cdot \text{ns}^{-1}$	ft/ns	ft/ns
name	symbol	value	baseunit	drvdunit	tradunit
\Ratom	r_{atom}	10^{-10}	m	m	m
name	symbol	value	baseunit	drvdunit	tradunit
\Mproton	m_p	1.6726×10^{-27}	kg	kg	kg
name	symbol	value	baseunit	drvdunit	tradunit
\Mneutron	m_n	1.6749×10^{-27}	kg	kg	kg
name	symbol	value	baseunit	drvdunit	tradunit
\Mhydrogen	m_H	1.6737×10^{-27}	kg	kg	kg
name	symbol	value	baseunit	drvdunit	tradunit
\Melectron	m_e	9.1094×10^{-31}	kg	kg	kg
name	symbol	value	baseunit	drvdunit	tradunit
\echarge	e	1.6022×10^{-19}	$\text{A} \cdot \text{s}$	C	C
name	symbol	value	baseunit	drvdunit	tradunit
\Qelectron	Q_e	-1.6022×10^{-19}	$\text{A} \cdot \text{s}$	C	C
name	symbol	value	baseunit	drvdunit	tradunit
\qelectron	q_e	-1.6022×10^{-19}	$\text{A} \cdot \text{s}$	C	C
name	symbol	value	baseunit	drvdunit	tradunit
\Qproton	Q_p	$+1.6022 \times 10^{-19}$	$\text{A} \cdot \text{s}$	C	C
name	symbol	value	baseunit	drvdunit	tradunit
\qproton	q_p	$+1.6022 \times 10^{-19}$	$\text{A} \cdot \text{s}$	C	C
name	symbol	value	baseunit	drvdunit	tradunit
\MEarth	M_{Earth}	5.9736×10^{24}	kg	kg	kg
name	symbol	value	baseunit	drvdunit	tradunit
\MMoon	M_{Moon}	7.3459×10^{22}	kg	kg	kg
name	symbol	value	baseunit	drvdunit	tradunit
\MSun	M_{Sun}	1.9891×10^{30}	kg	kg	kg

name	symbol	value	baseunit	drvdunit	tradunit
\REarth	R_{Earth}	6.3675×10^6	m	m	m
name	symbol	value	baseunit	drvdunit	tradunit
\RMoon	R_{Moon}	1.7375×10^6	m	m	m
name	symbol	value	baseunit	drvdunit	tradunit
\RSun	R_{Sun}	6.9634×10^8	m	m	m
name	symbol	value	baseunit	drvdunit	tradunit
\ESdist	$\ \vec{r}_{\text{ES}}\ $	1.4960×10^{11}	m	m	m
name	symbol	value	baseunit	drvdunit	tradunit
\EMdist	$\ \vec{r}_{\text{EM}}\ $	3.8440×10^8	m	m	m
name	symbol	value	baseunit	drvdunit	tradunit
\LSun	L_{Sun}	3.8460×10^{26}	$\text{m}^2 \cdot \text{kg} \cdot \text{s}^{-3}$	W	J/s
name	symbol	value	baseunit	drvdunit	tradunit
\TSun	T_{Sun}	5778	K	K	K
name	symbol	value	baseunit	drvdunit	tradunit
\MagSun	M_{Sun}	+4.83			
name	symbol	value	baseunit	drvdunit	tradunit
\magSun	m_{Sun}	-26.74			

5.11 Frequently Used Fractions

`\onehalf`

Small fractions with numerator 1 and denominators up to 10.

<code>\(\onehalf \cdots \onetenth\)</code>	$\frac{1}{2} \cdots \frac{1}{10}$
--	-----------------------------------

`\twooneths`

Small fractions with numerator 2 and denominators up to 10.

<code>\(\twooneths \cdots \twotenths\)</code>	$\frac{2}{1} \cdots \frac{2}{10}$
---	-----------------------------------

`\threonehths`

Small fractions with numerator 3 and denominators up to 10.

<code>\(\threonehths \cdots \threetenths\)</code>	$\frac{3}{1} \cdots \frac{3}{10}$
---	-----------------------------------

`\fouronehths`{*magnitude*}

Small fractions with numerator 4 and denominators up to 10.

<code>\(\fouronehths \cdots \fourtenths\)</code>	$\frac{4}{1} \cdots \frac{4}{10}$
--	-----------------------------------

5.12 Calculus

`\sumoverall`{*variable*}

Properly typesets summation over all of some user specified entities.

<code>\(\sumoverall{particles} \)</code>	$\sum_{\text{all particles}}$
---	-------------------------------

`\dx`{*variable*}

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

<code>\(\dx{y} \)</code>	dy
---------------------------	------

`\evalfromto`{*antiderivative*}{*lower*}{*upper*}

Properly typesets the evaluation of definite integrals.

<code>\(\evalfromto{\onethird y^3}{0}{3} \)</code>	$\left. \frac{1}{3}y^3 \right _0^3$
---	-------------------------------------

`\evalat`{*expression*}{*evaluationpoint*}

Properly typesets quantities evaluated at a particular point or value.

Combine with `\evaluatedat`?

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

$$\left. \frac{dx}{dt} \right|_{t=1}$$

`\evaluatedat{<evaluationpoint>}`

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

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

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

`\integral[<lower>][<upper>]{<integrand>}{<var>}`

Typesets indefinite and definite integrals.

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

$$\int y^2 dy$$
$$\int_{y=0}^{y=3} y^2 dy$$

`\opensurfaceintegral{<surfacename>}{<vectorname>}`

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

`\[\opensurfaceintegral{S}{\vect{E}} \]`

$$\iint_S \vec{E} \cdot \hat{n} dA$$

`\closedsurfaceintegral{<surfacename>}{<vectorname>}`

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

`\[\closedsurfaceintegral{S}{\vect{E}} \]`

$$\oiint_S \vec{E} \cdot \hat{n} dA$$

`\openlineintegral{<pathname>}{<vectorname>}`

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

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

$$\int_C \vec{E} \cdot \hat{t} d\ell$$

`\closedlineintegral{<pathname>}{<vectorname>}`

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

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

$$\oint_C \vec{E} \cdot \hat{t} d\ell$$

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.

`\volumeintegral{<volumename>}{<integrand>}`
 Integral over a volume.

`\[\volumeintegral{V}{\rho} \]`

$$\iiint_V \rho dV$$

`\dbydt[<operand>]`

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

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

$$\frac{d}{dt} \text{ or } \frac{d}{dt}x \text{ or } \frac{dx}{dt}$$

`\ddbydt[<operand>]`

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

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

$$\frac{d^2}{dt^2} \text{ or } \frac{d^2}{dt^2}x \text{ or } \frac{d^2x}{dt^2}$$

`\pbypt[<operand>]`

First partial time derivative operator.

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

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

`\ppbypt[<operand>]`

Second partial time derivative operator.

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

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

`\dbyd{<dependentvariable>}{<indvar>}`

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

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

$$\frac{df}{dy}$$

`\ddbyd{<dependentvariable>}{<indvar>}`

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

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

$$\frac{d^2f}{dy^2}$$

`\pbyp{<dependentvariable>}{<indvar>}`

Generic first partial derivative operator.

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

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

`\ppbyp{<dependentvariable>}{<indvar>}`

Generic second partial derivative operator.

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

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

`\gradient`

Gibbs' gradient operator. It's just an alias for `\nabla`.

`\gradient`

$$\nabla$$

`\divergence`

Gibbs' divergence operator.

`\divergence`

$$\nabla \cdot$$

`\curl`

Gibbs' curl operator.

`\curl`

$$\nabla \times$$

`\taigrad`

Tai's gradient operator. It's just an alias for `\nabla`.

`\taigrad`

$$\nabla$$

`\taisvec`

Tai's symbol for symbolic vector.

`\taisvec`

$$\nabla$$

`\taidivg`

Tai's symbol for divergence operator.

`\taidivg`

$$\nabla$$

`\taicurl`

Tai's symbol for curl operator.

`\taicurl`

$$\nabla$$

`\laplacian`

Laplacian operator.

`\laplacian`

$$\nabla^2$$

`\dalembertian`

D'Alembertian operator.

`\dalembertian`

□

`\seriesfofx`

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

`\seriesfofx`

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

`\seriesexp`

Series expansion of e^x .

`\seriesexp`

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

`\seriesinx`

Series expansion of $\sin x$.

`\seriesinx`

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

`\seriescosx`

Series expansion of $\cos x$.

`\seriescosx`

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

`\seriesanax`

Series expansion of $\tan x$.

`\seriesanax`

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

`\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`

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

`\diracdelta{<arg>}`
Dirac delta function.

`\diracdelta{x}`

$\delta(x)$

`\orderof{<arg>}`
Order of indicator.

`\orderof{x^2}`

$\mathcal{O}(x^2)$

5.13 Other Useful Commands

`\asin`

Symbol for inverse sine and other inverse circular trig functions.

<code>\(\asin, \acos, \atan, \asec, \acsc, \acot \)</code>	$\sin^{-1}, \cos^{-1}, \tan^{-1}, \sec^{-1}, \csc^{-1}, \cot^{-1}$
---	--

`\sech`

Hyperbolic and inverse hyperbolic functions not defined in L^AT_EX.

<code>\(\sech, \csch, \asinh, \acosh, \atanh, \) \asech, \acsch, \acoth \)</code>	$\operatorname{sech}, \operatorname{csch}, \sinh^{-1}, \cosh^{-1}, \tanh^{-1}, \operatorname{sech}^{-1}, \operatorname{csch}^{-1}, \operatorname{coth}^{-1}$
--	--

`\sgn{<arg>}`

Signum function.

<code>\(\sgn \)</code>	sgn
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`\dex`

Decimal exponentiation function (used in astrophysics).

<code>\(\dex \)</code>	dex
-------------------------	----------------------

`\logb[<base>]`

Logarithm to an arbitrary base.

<code>\logb 8, \logb[2] 8</code>	$\log 8, \log_2 8$
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`\cB`

Alternate symbol for magnetic field inspired by Tom Moore.

<code>\cB, \vect{\cB}</code>	cB, \vec{cB}
------------------------------	----------------

`\newpi`

Bob Palais' symbol for 2π .

<code>\newpi</code>	π
---------------------	-------

`\scripty{<kernel>}`

Command to get fonts in Griffiths' electrodynamics textbook.

<code>\scripty{r}</code>	$\scriptstyle r$
--------------------------	------------------

`\Lagr`

Command to get symbol for Lagrangian.

`\Lagr`

\mathcal{L}

`\flux[⟨label⟩]`

Symbol for flux of a vector field.

`\flux, \flux[E]`

Φ, Φ_E

`\inparens{⟨arg⟩}`

Surrounds with argument with parentheses. A blank argument generates a placeholder.

`\inparens{\onehalf}, \inparens{-3}, \inparens{}`

$(\frac{1}{2}), (-3), (\cdot)$

`\absf{⟨arg⟩}`

Absolute value function. A blank argument generates a placeholder.

`\absf{-4}, \absf{}`

$|-4|, |\cdot|$

`\magof{⟨arg⟩}`

Magnitude of a quantity (lets you selectively use double bars even when the **singleabsbars** option is use when loading the package). A blank argument generates a placeholder.

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

$\|\vec{E}\|, \|\cdot\|$

`\dimsof{⟨arg⟩}`

Notation for showing the dimensions of a quantity. A blank argument generates a placeholder.

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

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

`\unitsof{⟨arg⟩}`

Notation for showing the units of a quantity. I propose this notation and hope to propagate it because I could not find any standard notation for this same idea in other sources. A blank argument generates a placeholder.

`\unitsof{\vect{v}} = \velocityonlytradunit, \)`
`\unitsof{}`

$[\vec{v}]_u = \text{m/s}, [\cdot]_u$

`\Changein{⟨arg⟩}`

Notation for *the change in a quantity*.

`\Changein{\vect{E}}`

$\Delta \vec{E}$

`\scin[⟨mantissa⟩][⟨exponent⟩][⟨unit⟩]`

Command for scientific notation with an optional unit. Deprecated. Use `\timestento` or `\xtento` instead.

`2.99\timestento{8}[\velocityonlytradunit]`

$2.99 \times 10^8 \text{ m/s}$

`\xtento{<exponent>}[<unit>]`

Command for scientific notation with an optional unit. Alias for `\timestento`.

`2.99\xtento{8}[\velocityonlytradunit]`

$2.99 \times 10^8 \text{ m/s}$

`\ee{<mantissa>}{<exponent>}`

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

`\ee{2.99}{8}`

`2.99e8`

`\dms{<deg>}{<min>}{<sec>}`

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

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

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

`\clockreading{<hrs>}{<min>}{<sec>}`

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

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

$23^{\text{h}}34^{\text{m}}10.27^{\text{s}}$

`\latitude{<arg>}`

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

`\latitude{+35}, \latitudeN{35}, \latitudeS{35}`

$+35^\circ, 35^\circ \text{ N}, 35^\circ \text{ S}$

`\longitude{<arg>}`

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

`\longitude{-81}, \longitudeE{81}, \longitudeW{81}`

$-81^\circ, 81^\circ \text{ E}, 81^\circ \text{ W}$

`\ssup{<kernel>}{<sup>}`

Command for typesetting text superscripts.

`\ssup{N}{contact}`

N^{contact}

`\ssub{<kernel>}{<sub>}`

Command for typesetting text subscripts.

`\ssub{N}{AB}`

N_{AB}

`\ssud{<sup>}{<sub>}`

Command for typesetting text superscripts and subscripts.

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

N_{AB}^{contact}

`\msub{<kernel>}{<sub>}`

Command for typesetting mathematical subscripts.

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

$R_{\alpha\beta}$

`\msud{<kernel>}{<sup>}{<sub>}`

Command for typesetting mathematical superscripts and subscripts.

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

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

`\levicivita{<indices>}`

Command for Levi-Civita symbol.

`\levicivita{ijk}`

ε_{ijk}

`\kronecker{<indices>}`

Command for Kronecker delta symbol.

`\kronecker{ij}`

δ_{ij}

`\axis`

Command for coordinate axes.

`\xaxis, \yaxis, \zaxis`

x -axis, y -axis, z -axis

`\naxis[<axis>]`

Command for custom naming a coordinate axis.

`\naxis{t}`

t -axis

`\axis`

Suffix command for custom naming a coordinate axis. You are responsible for using math mode if necessary for the thing to which you apply the suffix.

`\(t\axis\)`

t -axis

`\xyplane`

Commands for naming coordinate planes. All combinations are defined.

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

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

`\plane`

Suffix command for custom naming a coordinate plane. You are responsible for using math mode if necessary for the thing to which you apply the suffix.

`\(xt)\plane`

xt-plane

`\fsqrt{<arg>}`

Command for square root as a fractional exponent.

`\fsqrt{x}`

$x^{\frac{1}{2}}$

`\cuberoot{<arg>}`

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

`\cuberoot{x}, \fcuberoot{x}`

$\sqrt[3]{x}, x^{\frac{1}{3}}$

`\fourthroot{<arg>}`

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

`\fourthroot{x}, \ffourthroot{x}`

$\sqrt[4]{x}, x^{\frac{1}{4}}$

`\fifthroot{<arg>}`

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

`\fifthroot{x}, \ffifthroot{x}`

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

`\relgamma{<arg>}`

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

```
\begin{align*}
\gamma&=\relgamma{\magvect{v}}\\
\gamma&=\relgamma{(0.5c)}\\
\gamma&=\frelgamma{\magvect{v}}\\
\gamma&=\frelgamma{(0.5c)}
\end{align*}
```

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

$$\gamma = \frac{1}{\sqrt{1 - \left(\frac{(0.5c)}{c}\right)^2}}$$

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

$$\gamma = \left(1 - \frac{(0.5c)^2}{c^2}\right)^{-\frac{1}{2}}$$

`\oosqrtomxs{<arg>}`

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

```
\oosqrtomxs{0.22},
\oosqrtomx{0.22},
\oosmx{0.22},
\oospx{0.11}
```

$$\frac{1}{\sqrt{1-0.22^2}}, \frac{1}{\sqrt{1-0.22}}, \frac{1}{1-0.22}, \frac{1}{1+0.11}$$

5.14 Custom Operators

The = operator is frequently misused. We need other operators for other cases.

`\isequals`

Command for *test-for-equality* operator.

```
5 \isequals 3
```

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

`\wordoperator{<firstline>}{<secondline>}`

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

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

added
to
(added
to)

`\definedas`

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

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

defined and associated and adjusted
as with and by
earlier later than and for
than and than and every
(defined) and (associated) and (adjusted)
(as with for)
(earlier) and (later) and (every)

`\defines`

Command for *defines* or *defined by* operator.

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

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

`\inframe[<frame>]`

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

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

$$\vec{p} \xrightarrow{S} (1, 2, 3) \text{ kg} \cdot \text{m/s}$$
$$\vec{p} \xrightarrow{S'} \langle \sqrt{14}, 0, 0 \rangle \text{ kg} \cdot \text{m/s}$$

Make the arrow's length fixed.

`\associates`

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

`kinetic energy \associates velocity`

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

`\becomes`

Command for *becomes* operator.

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

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

`\rrelatedto{<leftoperation>}`

Command for left-to-right relationship.

`(flux ratio) \rrelatedto{taking logarithm} (mag \> \<diff)`

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

`\lrelatedto{<roperation>}`

Command for right-to-left relationship.

`(flux ratio) \lrelatedto{exponentiation} (mag \> \<diff)`

(flux ratio) $\xleftarrow{\text{exponentiation}}$ (mag diff)

`\brelatedto{<leftoperation>}{<roperation>}`

Command for bidirectional relationship.

`(mag diff) \brelatedto{taking \> \<logarithm}{exponentiation}(flux ratio)`

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

5.15 Commands Specific to *Matter & Interactions*

`\momentumprinciple`

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

`\momentumprinciple`

$\vec{p}_{\text{sys,final}} = \vec{p}_{\text{sys,initial}} + \vec{F}_{\text{net,sys}} \Delta t$

`\momentumprinciplediff`

Expression for the momentum principle in differential form.

`\momentumprinciplediff`

$\Delta \vec{p}_{\text{sys}} = \vec{F}_{\text{net,sys}} \Delta t$

`\energyprinciple`

Expression for the energy principle. Prepend `\LHS` to get just the left hand side and `\RHS` to get just the right hand side. Processes other than work and thermal energy transfer (e.g. radiation) are neglected.

`\energyprinciple`

$$E_{\text{sys,final}} = E_{\text{sys,initial}} + W + Q$$

`\energyprinciplediff`

Expression for the energy principle in differential form.

`\energyprinciplediff`

$$\Delta E_{\text{sys}} = W + Q$$

`\angularmomentumprinciple`

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

`\angularmomentumprinciple`

$$\vec{L}_{A,\text{sys,final}} = \vec{L}_{A,\text{sys,initial}} + \vec{\tau}_{A,\text{net}} \Delta t$$

`\angularmomentumprinciplediff`

Expression for the angular momentum principle in differential form.

`\angularmomentumprinciplediff`

$$\Delta \vec{L}_{A,\text{sys}} = \vec{\tau}_{A,\text{net}} \Delta t$$

`\gravitationalinteraction`

Expression for gravitational interaction.

`\gravitationalinteraction`

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

`\electricinteraction`

Expression for electric interaction.

`\electricinteraction`

$$\frac{1}{4\pi\epsilon_0} \frac{Q_1 Q_2}{\|\vec{r}_{12}\|^2} \hat{r}_{12}$$

`\springinteraction`

Expression for spring interaction.

`\springinteraction`

$$k_s \|\vec{s}\| (-\hat{s})$$

`\Efieldofparticle`

Expression for a particle's electric field.

`\Efieldofparticle`

$$\frac{1}{4\pi\epsilon_0} \frac{Q}{\|\vec{r}\|^2} \hat{r}$$

`\Bfieldofparticle`

Expression for a particle's magnetic field.

`\Bfieldofparticle`

$$-\frac{\mu_0}{4\pi} \frac{Q \|\vec{v}\|}{\|\vec{r}\|^2} \hat{v} \times \hat{r}$$

In the commands that take an optional label, note how to specify initial and final values of quantities.

`\Esys[⟨label⟩]`

Symbol for system energy.

`\Esys`, `\Esys[final]`, `\Esys[initial]`

E_{sys} , $E_{\text{sys,final}}$, $E_{\text{sys,initial}}$

`\Us[⟨label⟩]`

Symbol for spring potential energy.

`\Us`, `\Us[final]`, `\Us[initial]`

U_s , $U_{s,\text{final}}$, $U_{s,\text{initial}}$

`\Ug[⟨label⟩]`

Symbol for gravitational potential energy.

`\Ug`, `\Ug[final]`, `\Ug[initial]`

U_g , $U_{g,\text{final}}$, $U_{g,\text{initial}}$

`\Ue[⟨label⟩]`

Symbol for electric potential energy.

`\Ue`, `\Ue[final]`, `\Ue[initial]`

U_e , $U_{e,\text{final}}$, $U_{e,\text{initial}}$

`\Ktrans[⟨label⟩]`

Symbol for translational kinetic energy.

`\Ktrans`, `\Ktrans[final]`, `\Ktrans[initial]`

K_{trans} , $K_{\text{trans,final}}$, $K_{\text{trans,initial}}$

`\Krot[⟨label⟩]`

Symbol for rotational kinetic energy.

`\Krot`, `\Krot[final]`, `\Krot[initial]`

K_{rot} , $K_{\text{rot,final}}$, $K_{\text{rot,initial}}$

`\Kvib[⟨label⟩]`

Symbol for vibrational kinetic energy.

`\Kvib`, `\Evib[final]`, `\Evib[initial]`

K_{vib} , $E_{\text{vib,final}}$, $E_{\text{vib,initial}}$

`\Eparticle[⟨label⟩]`

Symbol for particle energy.

`\Eparticle`, `\Eparticle[final]`, `\Eparticle[initial]`

E_{particle} , $E_{\text{particle,final}}$, $E_{\text{particle,initial}}$

`\Einternal[⟨label⟩]`

Symbol for internal energy.

`\Einternal`, `\Einternal[final]`, `\Einternal[initial]`

E_{internal} , $E_{\text{internal,final}}$, $E_{\text{internal,initial}}$

`\Erest[⟨label⟩]`

Symbol for rest energy.

`\Erest`, `\Erest[final]`, `\Erest[initial]`

E_{rest} , $E_{\text{rest,final}}$, $E_{\text{rest,initial}}$

`\Echem[⟨label⟩]`

Symbol for chemical energy.

`\Echem`, `\Echem[final]`, `\Echem[initial]`

E_{chem} , $E_{\text{chem,final}}$, $E_{\text{chem,initial}}$

`\Etherm[⟨label⟩]`

Symbol for thermal energy.

`\Etherm`, `\Etherm[final]`, `\Etherm[initial]`

E_{therm} , $E_{\text{therm,final}}$, $E_{\text{therm,initial}}$

`\Evib[⟨label⟩]`

Symbol for vibrational energy.

`\Evib`, `\Evib[final]`, `\Evib[initial]`

E_{vib} , $E_{\text{vib,final}}$, $E_{\text{vib,initial}}$

`\Ephoton[⟨label⟩]`

Symbol for photon energy.

`\Ephoton`, `\Ephoton[final]`, `\Ephoton[initial]`

E_{photon} , $E_{\text{photon,final}}$, $E_{\text{photon,initial}}$

`\DEsys`

Symbol for change in system energy.

`\DEsys`

ΔE_{sys}

`\DUs`

Symbol for change in spring potential energy.

`\DUs`

ΔU_s

`\DUg`

Symbol for change in gravitational potential energy.

`\DUg`

ΔU_g

`\DUe`

Symbol for change in electric potential energy.

`\DUe`

ΔU_e

\DKtrans

Symbol for change in translational kinetic energy.

`\DKtrans`

ΔK_{trans}

\DKrot

Symbol for change in rotational kinetic energy.

`\DKrot`

ΔK_{rot}

\DKvib

Symbol for change in vibrational kinetic energy.

`\DKvib`

ΔK_{vib}

\DEparticle

Symbol for change in particle energy.

`\DEparticle`

$\Delta E_{\text{particle}}$

\DEinternal

Symbol for change in internal energy.

`\DEinternal`

$\Delta E_{\text{internal}}$

\DERest

Symbol for change in rest energy.

`\DERest`

ΔE_{rest}

\DEchem

Symbol for change in chemical energy.

`\DEchem`

ΔE_{chem}

\DEtherm

Symbol for change in thermal energy.

`\DEtherm`

ΔE_{therm}

\DEvib

Symbol for change in vibrational energy.

`\DEvib`

ΔE_{vib}

`\DEphoton`

Symbol for change in photon energy.

`\DEphoton`

ΔE_{photon}

`\springpotentialenergy`

Expression for spring potential energy.

`\springpotentialenergy`

$\frac{1}{2} k_s \|\vec{s}\|^2$

`\finalspringpotentialenergy`

Expression for final spring potential energy.

`\finalspringpotentialenergy`

$\left(\frac{1}{2} k_s \|\vec{s}\|^2\right)_{\text{final}}$

`\initialspringpotentialenergy`

Expression for initial spring potential energy.

`\initialspringpotentialenergy`

$\left(\frac{1}{2} k_s \|\vec{s}\|^2\right)_{\text{initial}}$

`\electricpotentialenergy`

Expression for electric potential energy.

`\electricpotentialenergy`

$\frac{1}{4\pi\epsilon_0} \frac{Q_1 Q_2}{\|\vec{r}_{12}\|}$

`\finalelectricpotentialenergy`

Expression for final electric potential energy.

`\finalelectricpotentialenergy`

$\left(\frac{1}{4\pi\epsilon_0} \frac{Q_1 Q_2}{\|\vec{r}_{12}\|}\right)_{\text{final}}$

`\initialelectricpotentialenergy`

Expression for initial electric potential energy.

`\initialelectricpotentialenergy`

$\left(\frac{1}{4\pi\epsilon_0} \frac{Q_1 Q_2}{\|\vec{r}_{12}\|}\right)_{\text{initial}}$

`\gravitationalpotentialenergy`

Expression for gravitational potential energy.

`\gravitationalpotentialenergy`

$-G \frac{M_1 M_2}{\|\vec{r}_{12}\|}$

`\finalgravitationalpotentialenergy`

Expression for final gravitational potential energy.

`\finalgravitationalpotentialenergy`

$$\left(-G \frac{M_1 M_2}{\|\vec{r}_{12}\|}\right)_{\text{final}}$$

`\initialgravitationalpotentialenergy`

Expression for initial gravitational potential energy.

`\initialgravitationalpotentialenergy`

$$\left(-G \frac{M_1 M_2}{\|\vec{r}_{12}\|}\right)_{\text{initial}}$$

`\ks`

Symbol for spring stiffness.

`\ks`

k_s

`\Fnet`

Various symbols for net force.

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

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

`\Tnet`

Various symbols for net torque.

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

$$\vec{\tau}_{A,\text{net}}, \vec{\tau}_{A,\text{net,ext}}, \vec{\tau}_{A,\text{net,sys}}, \vec{\tau}_{A,\text{ball}}$$

`\Ltotal`

Various symbols for total angular momentum.

`\Ltotal, \Lsys, \Lsub{ball}`

$$\vec{L}_{A,\text{total}}, \vec{L}_{A,\text{sys}}, \vec{L}_{A,\text{ball}}$$

`\LHSmaxwelliint` [*surfacename*]

Left hand side of Maxwell's first equation in integral form. Note the default value of the optional argument.

```
\begin{align*}
&\&\LHSmaxwelliint \ \
&\&\LHSmaxwelliint [S]
\end{align*}
```

$$\oiint_{\partial V} \vec{E} \cdot \hat{n} \, dA$$
$$\oiint_S \vec{E} \cdot \hat{n} \, dA$$

`\RHSmaxwelliint`

Right hand side of Maxwell's first equation in integral form.

`\[\RHSmaxwelliint \]`

$$\frac{Q_{e,\text{net}}}{\epsilon_0}$$

`\RHSmaxwelliinta` [*volumename*]

Alternate form of right hand side of Maxwell's first equation in integral form. Note the default value of the optional argument.

```

\begin{align*}
&\&\text{RHSmaxwelliinta} \ \ \ \\
&\&\text{RHSmaxwelliinta}[\text{\epsilon}] \\
\end{align*}

```

$$\frac{1}{\epsilon_0} \iiint_V \rho_e \, dV$$

$$\frac{1}{\epsilon_0} \iiint_v \rho_e \, dV$$

`\RHSmaxwelliintfree`

Right hand side of Maxwell's first equation in integral form in free space.

```

\ [ \RHSmaxwelliintfree \ ]

```

0

`\maxwelliint`[*<surfacename>*]

Maxwell's first equation in integral form. Note the default value of the optional argument.

```

\begin{align*}
&\&\text{maxwelliint} \ \ \ \\
&\&\text{maxwelliint}[\text{S}] \\
\end{align*}

```

$$\oiint_{\partial V} \vec{E} \cdot \hat{n} \, dA = \frac{Q_{e,\text{net}}}{\epsilon_0}$$

$$\oiint_S \vec{E} \cdot \hat{n} \, dA = \frac{Q_{e,\text{net}}}{\epsilon_0}$$

`\maxwelliinta`[*<surfacename>*][*<volumename>*]

Alternate form of Maxwell's first equation in integral form. Note the default values of the optional arguments.

```

\begin{align*}
&\&\text{maxwelliinta} \ \ \ \\
&\&\text{maxwelliinta}[\text{S}][\text{\epsilon}] \\
\end{align*}

```

$$\oiint_{\partial V} \vec{E} \cdot \hat{n} \, dA = \frac{1}{\epsilon_0} \iiint_V \rho_e \, dV$$

$$\oiint_S \vec{E} \cdot \hat{n} \, dA = \frac{1}{\epsilon_0} \iiint_v \rho_e \, dV$$

`\maxwelliintfree`[*<surfacename>*]

Maxwell's first equation in integral form in free space. Note the default value of the optional argument.

```

\begin{align*}
&\&\text{maxwelliintfree} \ \ \ \\
&\&\text{maxwelliintfree}[\text{S}] \\
\end{align*}

```

$$\oiint_{\partial V} \vec{E} \cdot \hat{n} \, dA = 0$$

$$\oiint_S \vec{E} \cdot \hat{n} \, dA = 0$$

`\LHSmaxwelliint`[*<surfacename>*]

Left hand side of Maxwell's second equation in integral form. Note the default value of the optional argument.

```

\begin{align*}
&\&\text{LHSmaxwelliint} \ \ \ \\
&\&\text{LHSmaxwelliint}[\text{S}] \\
\end{align*}

```

$$\oiint_{\partial V} \vec{B} \cdot \hat{n} \, dA$$

$$\oiint_S \vec{B} \cdot \hat{n} \, dA$$

`\RHSmaxwelliint`

Right hand side of Maxwell's second equation in integral form.

```
\[ \RHSmaxwelliint \]
```

 0

`\RHSmaxwelliintm`

Right hand side of Maxwell's second equation in integral form with magnetic monopoles.

```
\[ \RHSmaxwelliintm \]
```

 $\mu_0 Q_{m,net}$

`\RHSmaxwelliintma` [*volumename*]

Alternate form of right hand side of Maxwell's second equation in integral form with magnetic monopoles. Note the default value of the optional argument.

```
\begin{align*} &\&\RHSmaxwelliintma \ \ \\ &\&\RHSmaxwelliintma[\upsilon] \\ \end{align*}
```

$$\mu_0 \iiint_V \rho_m dV$$
$$\mu_0 \iiint_{\upsilon} \rho_m dV$$

`\RHSmaxwelliintfree`

Right hand side of Maxwell's second equation in integral form in free space.

```
\[ \RHSmaxwelliintfree \]
```

 0

`\maxwelliint` [*surfacename*]

Maxwell's second equation in integral form. Note the default value of the optional argument.

```
\begin{align*} &\&\maxwelliint \ \ \\ &\&\maxwelliint[S] \\ \end{align*}
```

$$\oiint_{\partial V} \vec{B} \cdot \hat{n} dA = 0$$
$$\oiint_S \vec{B} \cdot \hat{n} dA = 0$$

`\maxwelliintm` [*surfacename*]

Maxwell's second equation in integral form with magnetic monopoles. Note the default value of the optional argument.

```
\begin{align*} &\&\maxwelliintm \ \ \\ &\&\maxwelliintm[S] \\ \end{align*}
```

$$\oiint_{\partial V} \vec{B} \cdot \hat{n} dA = \mu_0 Q_{m,net}$$
$$\oiint_S \vec{B} \cdot \hat{n} dA = \mu_0 Q_{m,net}$$

`\maxwelliintma` [*surfacename*] [*volumename*]

Alternate form of Maxwell's second equation in integral form with magnetic monopoles. Note the default values of the optional arguments.


```

\begin{align*}
&\&\maxwelliiintma \ \
&\maxwelliiintma[S][\upsilon]
\end{align*}

```

$$\oiint_{\partial V} \vec{B} \cdot \hat{n} \, dA = \mu_0 \iiint_V \rho_m \, dV$$

$$\oiint_S \vec{B} \cdot \hat{n} \, dA = \mu_0 \iiint_V \rho_m \, dV$$

`\maxwelliiintfree` [*surfacename*]

Maxwell's second equation in integral form in free space. Note the default value of the optional argument.

```

\begin{align*}
&\&\maxwelliiintfree \ \
&\maxwelliiintfree[S]
\end{align*}

```

$$\oiint_{\partial V} \vec{B} \cdot \hat{n} \, dA = 0$$

$$\oiint_S \vec{B} \cdot \hat{n} \, dA = 0$$

`\LHSmaxwelliiint` [*boundaryname*]

Left hand side of Maxwell's third equation in integral form. Note the default value of the optional argument.

```

\begin{align*}
&\&\LHSmaxwelliiint \ \
&\LHSmaxwelliiint[C]
\end{align*}

```

$$\oint_{\partial \Omega} \vec{E} \cdot \hat{t} \, d\ell$$

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

`\RHSmaxwelliiint` [*surfacename*]

Right hand side of Maxwell's third equation in integral form. Note the default value of the optional argument.

```

\begin{align*}
&\&\RHSmaxwelliiint \ \
&\RHSmaxwelliiint[S]
\end{align*}

```

$$-\frac{d}{dt} \iint_{\Omega} \vec{B} \cdot \hat{n} \, dA$$

$$-\frac{d}{dt} \iint_S \vec{B} \cdot \hat{n} \, dA$$

`\RHSmaxwelliiintm` [*surfacename*]

Right hand side of Maxwell's third equation in integral form with magnetic monopoles. Note the default value of the optional argument.

```

\begin{align*}
&\&\RHSmaxwelliiintm \ \
&\RHSmaxwelliiintm[S]
\end{align*}

```

$$-\frac{d}{dt} \iint_{\Omega} \vec{B} \cdot \hat{n} \, dA - \mu_0 I_{m,net}$$

$$-\frac{d}{dt} \iint_S \vec{B} \cdot \hat{n} \, dA - \mu_0 I_{m,net}$$

`\RHSmaxwelliiintma` [*surfacename*]

Alternate form of right hand side of Maxwell's third equation in integral form with magnetic monopoles. Note the default value of the optional argument.

```

\begin{align*}
&\&\text{RHSmaxwelliiiintma} \ \ \ \\
&\&\text{RHSmaxwelliiiintma}[S] \\
\end{align*}

```

$$\begin{aligned}
&-\frac{d}{dt} \iint_{\Omega} \vec{B} \cdot \hat{n} \, dA - \mu_0 \iint_{\Omega} \vec{J}_m \cdot \hat{n} \, dA \\
&-\frac{d}{dt} \iint_S \vec{B} \cdot \hat{n} \, dA - \mu_0 \iint_S \vec{J}_m \cdot \hat{n} \, dA
\end{aligned}$$

`\RHSmaxwelliiiintfree` [*surfacename*]

Right hand side of Maxwell's third equation in integral form in free space. Note the default value of the optional argument.

```

\begin{align*}
&\&\text{RHSmaxwelliiiintfree} \ \ \ \\
&\&\text{RHSmaxwelliiiintfree}[S] \\
\end{align*}

```

$$\begin{aligned}
&-\frac{d}{dt} \iint_{\Omega} \vec{B} \cdot \hat{n} \, dA \\
&-\frac{d}{dt} \iint_S \vec{B} \cdot \hat{n} \, dA
\end{aligned}$$

`\maxwelliiiint` [*boundaryname*] [*surfacename*]

Maxwell's third equation in integral form. Note the default values of the optional arguments.

```

\begin{align*}
&\&\text{maxwelliiiint} \ \ \ \\
&\&\text{maxwelliiiint}[C][S] \\
\end{align*}

```

$$\begin{aligned}
\oint_{\partial\Omega} \vec{E} \cdot \hat{t} \, dl &= -\frac{d}{dt} \iint_{\Omega} \vec{B} \cdot \hat{n} \, dA \\
\oint_C \vec{E} \cdot \hat{t} \, dl &= -\frac{d}{dt} \iint_S \vec{B} \cdot \hat{n} \, dA
\end{aligned}$$

`\maxwelliiiintm` [*boundaryname*] [*surfacename*]

Maxwell's third equation in integral form with magnetic monopoles. Note the default values of the optional arguments.

```

\begin{align*}
&\&\text{maxwelliiiintm} \ \ \ \\
&\&\text{maxwelliiiintm}[C][S] \\
\end{align*}

```

$$\begin{aligned}
\oint_{\partial\Omega} \vec{E} \cdot \hat{t} \, dl &= -\frac{d}{dt} \iint_{\Omega} \vec{B} \cdot \hat{n} \, dA - \mu_0 I_{m,net} \\
\oint_C \vec{E} \cdot \hat{t} \, dl &= -\frac{d}{dt} \iint_S \vec{B} \cdot \hat{n} \, dA - \mu_0 I_{m,net}
\end{aligned}$$

`\maxwelliiiintma` [*boundaryname*] [*surfacename*]

Alternate form of Maxwell's third equation in integral form with magnetic monopoles. Note the default values of the optional arguments.

```

\begin{align*}
&\&\text{maxwelliiiintma} \ \ \ \\
&\&\text{maxwelliiiintma}[C][S] \\
\end{align*}

```

$$\begin{aligned}
\oint_{\partial\Omega} \vec{E} \cdot \hat{t} \, dl &= -\frac{d}{dt} \iint_{\Omega} \vec{B} \cdot \hat{n} \, dA - \mu_0 \iint_{\Omega} \vec{J}_m \cdot \hat{n} \, dA \\
\oint_C \vec{E} \cdot \hat{t} \, dl &= -\frac{d}{dt} \iint_S \vec{B} \cdot \hat{n} \, dA - \mu_0 \iint_S \vec{J}_m \cdot \hat{n} \, dA
\end{aligned}$$

`\maxwelliiiintfree` [*boundaryname*] [*surfacename*]

Maxwell's third equation in integral form in free space. Note the default values of the optional arguments.

```

\begin{align*}
&\&\maxwelliiintfree \ \
&\maxwelliiintfree[C][S]
\end{align*}

```

$$\oint_{\partial\Omega} \vec{E} \cdot \hat{t} \, dl = -\frac{d}{dt} \iint_{\Omega} \vec{B} \cdot \hat{n} \, dA$$

$$\oint_C \vec{E} \cdot \hat{t} \, dl = -\frac{d}{dt} \iint_S \vec{B} \cdot \hat{n} \, dA$$

`\LHSmaxwellivint` [*boundaryname*]

Left hand side of Maxwell's fourth equation in integral form. Note the default value of the optional argument.

```

\begin{align*}
&\&\LHSmaxwellivint \ \
&\LHSmaxwellivint[C]
\end{align*}

```

$$\oint_{\partial\Omega} \vec{B} \cdot \hat{t} \, dl$$

$$\oint_C \vec{B} \cdot \hat{t} \, dl$$

`\RHSmaxwellivint` [*surfacename*]

Right hand side of Maxwell's fourth equation in integral form. Note the default value of the optional argument.

```

\begin{align*}
&\&\RHSmaxwellivint \ \
&\RHSmaxwellivint[S]
\end{align*}

```

$$\mu_0\epsilon_0 \frac{d}{dt} \iint_{\Omega} \vec{E} \cdot \hat{n} \, dA + \mu_0 I_{e,net}$$

$$\mu_0\epsilon_0 \frac{d}{dt} \iint_S \vec{E} \cdot \hat{n} \, dA + \mu_0 I_{e,net}$$

`\RHSmaxwellivinta` [*surfacename*]

Alternate form of right hand side of Maxwell's fourth equation in integral form. Note the default value of the optional argument.

```

\begin{align*}
&\&\RHSmaxwellivinta \ \
&\RHSmaxwellivinta[S]
\end{align*}

```

$$\mu_0\epsilon_0 \frac{d}{dt} \iint_{\Omega} \vec{E} \cdot \hat{n} \, dA + \mu_0 \iint_{\Omega} \vec{J}_e \cdot \hat{n} \, dA$$

$$\mu_0\epsilon_0 \frac{d}{dt} \iint_S \vec{E} \cdot \hat{n} \, dA + \mu_0 \iint_S \vec{J}_e \cdot \hat{n} \, dA$$

`\RHSmaxwellivintfree` [*surfacename*]

Right hand side of Maxwell's fourth equation in integral form in free space. Note the default value of the optional argument.

```

\begin{align*}
&\&\RHSmaxwellivintfree \ \
&\RHSmaxwellivintfree[S]
\end{align*}

```

$$\mu_0\epsilon_0 \frac{d}{dt} \iint_{\Omega} \vec{E} \cdot \hat{n} \, dA$$

$$\mu_0\epsilon_0 \frac{d}{dt} \iint_S \vec{E} \cdot \hat{n} \, dA$$

`\maxwellivint` [*boundaryname*] [*surfacename*]

Maxwell's fourth equation in integral form. Note the default values of the optional arguments.

```
\begin{align*}
&\&\maxwellivint \ \
&\maxwellivint[C][S]
\end{align*}
```

$$\oint_{\partial\Omega} \vec{B} \cdot \hat{t} \, dl = \mu_0 \epsilon_0 \frac{d}{dt} \iint_{\Omega} \vec{E} \cdot \hat{n} \, dA + \mu_0 I_{e,\text{net}}$$

$$\oint_C \vec{B} \cdot \hat{t} \, dl = \mu_0 \epsilon_0 \frac{d}{dt} \iint_S \vec{E} \cdot \hat{n} \, dA + \mu_0 I_{e,\text{net}}$$

`\maxwellivinta` [*boundaryname*] [*surfacename*]

Alternate form of Maxwell's fourth equation in integral form. Note the default values of the optional arguments.

```
\begin{align*}
&\&\maxwellivinta \ \
&\maxwellivinta[C][S]
\end{align*}
```

$$\oint_{\partial\Omega} \vec{B} \cdot \hat{t} \, dl = \mu_0 \epsilon_0 \frac{d}{dt} \iint_{\Omega} \vec{E} \cdot \hat{n} \, dA + \mu_0 \iint_{\Omega} \vec{J}_e \cdot \hat{n} \, dA$$

$$\oint_C \vec{B} \cdot \hat{t} \, dl = \mu_0 \epsilon_0 \frac{d}{dt} \iint_S \vec{E} \cdot \hat{n} \, dA + \mu_0 \iint_S \vec{J}_e \cdot \hat{n} \, dA$$

`\maxwellivintfree` [*boundaryname*] [*surfacename*]

Maxwell's fourth equation in integral form in free space. Note the default values of the optional arguments.

```
\begin{align*}
&\&\maxwellivintfree \ \
&\maxwellivintfree[C][S]
\end{align*}
```

$$\oint_{\partial\Omega} \vec{B} \cdot \hat{t} \, dl = \mu_0 \epsilon_0 \frac{d}{dt} \iint_{\Omega} \vec{E} \cdot \hat{n} \, dA$$

$$\oint_C \vec{B} \cdot \hat{t} \, dl = \mu_0 \epsilon_0 \frac{d}{dt} \iint_S \vec{E} \cdot \hat{n} \, dA$$

`\LHSmaxwellidif`

Left hand side of Maxwell's first equation in differential form.

```
\[ \LHSmaxwellidif \]
```

$$\nabla \cdot \vec{E}$$

`\RHSmaxwellidif`

Right hand side of Maxwell's first equation in differential form.

```
\[ \RHSmaxwellidif \]
```

$$\frac{\rho_e}{\epsilon_0}$$

`\RHSmaxwellidiffree`

Right hand side of Maxwell's first equation in differential form in free space.

```
\[ \RHSmaxwellidiffree \]
```

$$0$$

`\maxwellidif`

Maxwell's first equation in differential form.

```
\[ \maxwellidif \]
```

$$\nabla \cdot \vec{E} = \frac{\rho_e}{\epsilon_0}$$

`\maxwellidiffree`

Maxwell's first equation in differential form in free space.

`\[\maxwelliidiffree \]`

$$\nabla \cdot \vec{E} = 0$$

`\LHSmaxwelliidif`

Left hand side of Maxwell's second equation in differential form.

`\[\LHSmaxwelliidif \]`

$$\nabla \cdot \vec{B}$$

`\RHSmaxwelliidif`

Right hand side of Maxwell's second equation in differential form.

`\[\RHSmaxwelliidif \]`

$$0$$

`\RHSmaxwelliidifm`

Right hand side of Maxwell's second equation in differential form with magnetic monopoles.

`\[\RHSmaxwelliidifm \]`

$$\mu_0 \rho_m$$

`\RHSmaxwelliidiffree`

Right hand side of Maxwell's second equation in differential form in free space.

`\[\RHSmaxwelliidiffree \]`

$$0$$

`\maxwelliidif`

Maxwell's second equation in differential form.

`\[\maxwelliidif \]`

$$\nabla \cdot \vec{B} = 0$$

`\maxwelliidifm`

Maxwell's second equation in differential form with magnetic monopoles.

`\[\maxwelliidifm \]`

$$\nabla \cdot \vec{B} = \mu_0 \rho_m$$

`\maxwelliidiiffree`

Maxwell's second equation in differential form in free space.

`\[\maxwelliidiiffree \]`

$$\nabla \cdot \vec{B} = 0$$

`\LHSmaxwelliidif`

Left hand side of Maxwell's third equation in differential form.

`\[\LHSmaxwelliidif \]`

$$\nabla \times \vec{E}$$

`\RHSmaxwelliidif`

Right hand side of Maxwell's third equation in differential form.

`\[\RHSmaxwelliidif \]`

$$-\frac{\partial \vec{B}}{\partial t}$$

`\RHSmaxwelliidifm`

Right hand side of Maxwell's third equation in differential form with magnetic monopoles.

`\[\RHSmaxwelliidifm \]`

$$-\frac{\partial \vec{B}}{\partial t} - \mu_0 \vec{J}_m$$

`\RHSmaxwelliidiffree`

Right hand side of Maxwell's third equation in differential form in free space.

`\[\RHSmaxwelliidiffree \]`

$$-\frac{\partial \vec{B}}{\partial t}$$

`\maxwelliidif`

Maxwell's third equation in differential form.

`\[\maxwelliidif \]`

$$\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$$

`\maxwelliidifm`

Maxwell's third equation in differential form with magnetic monopoles.

`\[\maxwelliidifm \]`

$$\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t} - \mu_0 \vec{J}_m$$

`\maxwelliidiffree`

Maxwell's third equation in differential form in free space.

`\[\maxwelliidiffree \]`

$$\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$$

`\LHSmaxwellivdif`

Left hand side of Maxwell's fourth equation in differential form.

`\[\LHSmaxwellivdif \]`

$$\nabla \times \vec{B}$$

`\RHSmaxwellivdif`

Right hand side of Maxwell's fourth equation in differential form.

`\[\RHSmaxwellivdif \]`

$$\mu_0 \epsilon_0 \frac{\partial \vec{E}}{\partial t} + \mu_0 \vec{J}_e$$

`\RHSmaxwellivdiffree`

Right hand side of Maxwell's fourth equation in differential form in free space.

`\[\RHSmaxwellivdiffree \]`

$$\mu_0 \epsilon_0 \frac{\partial \vec{E}}{\partial t}$$

`\maxwellivdif`

Maxwell's fourth equation in differential form.

`\[\maxwellivdif \]`

$$\nabla \times \vec{B} = \mu_0 \epsilon_0 \frac{\partial \vec{E}}{\partial t} + \mu_0 \vec{J}_e$$

`\maxwellivdiffree`

Maxwell's fourth equation in differential form in free space.

`\[\maxwellivdiffree \]`

$$\nabla \times \vec{B} = \mu_0 \epsilon_0 \frac{\partial \vec{E}}{\partial t}$$

`\RHSlorentzforce`

Right hand side of Lorentz force.

`\[\RHSlorentzforce \]`

$$q_e (\vec{E} + \vec{v} \times \vec{B})$$

`\RHSlorentzforcem`

Right hand side of Lorentz force with magnetic monopoles.

`\[\RHSlorentzforcem \]`

$$q_e (\vec{E} + \vec{v} \times \vec{B}) + q_m \left(\vec{B} - \vec{v} \times \frac{\vec{E}}{c^2} \right)$$

`\eulerlagrange[⟨operand⟩]`

Euler-Lagrange equation. Use `\Eulerlagrange` to get Δ instead of ∂ .

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

$$\frac{\partial \mathcal{L}}{\partial q_i} - \frac{d}{dt} \left(\frac{\partial \mathcal{L}}{\partial \dot{q}_i} \right) = 0 \text{ or } \frac{\partial \mathcal{L}}{\partial x} - \frac{d}{dt} \left(\frac{\partial \mathcal{L}}{\partial \dot{x}} \right) = 0$$

5.16 VPython and GlowScript Code

There are three ways to deal with VPython² and GlowScript³ code.

`\vpythonline{⟨vpythoncode⟩}`

Command for a single line of VPython or GlowScript code used inline.

`\vpythonline{from __future__ import division, }
{print_function}`

`from __future__ import division,
print_function`

²See the VPython home page at <http://vpython.org/> for more information.

³See the GlowScript home page at <http://glowsript.org/> for more information.

```
\begin{vpythonblock}[<caption>]
  <environment content>
\end{vpythonblock}
```

Environment for a block of VPython or GlowScript code.

```
\begin{vpythonblock}[Example VPython Listing]
  from __future__ import division,print_function
  from visual import *
  sphere(pos=vector(1,2,3),color=color.green)
  # create a named arrow
  MyArrow=arrow(pos=earth.pos,axis=fscale*Fnet,color=color.green)
  print ("arrow.pos = "), arrow.pos
\end{vpythonblock}
\begin{vpythonblock}[Example GlowScript Listing]
  GlowScript 2.0 VPython
  sphere(pos=vector(1,2,3),color=color.green)
  # create a named arrow
  MyArrow=arrow(pos=earth.pos,axis=fscale*Fnet,color=color.green)
  print ("arrow.pos = "), arrow.pos
\end{vpythonblock}
```

```
1  from __future__ import division , print _ function
2  from visual import *
3  sphere ( pos = vector ( 1 , 2 , 3 ) , color = color . green )
4  # create a named arrow
5  MyArrow = arrow ( pos = earth . pos , axis = fscale * Fnet , color = color . green )
6  print ( "arrow.pos = " ) , arrow . pos
```

Listing 1: Example VPython Listing

```
1  GlowScript 2.0 VPython
2  sphere ( pos = vector ( 1 , 2 , 3 ) , color = color . green )
3  # create a named arrow
4  MyArrow = arrow ( pos = earth . pos , axis = fscale * Fnet , color = color . green )
5  print ( "arrow.pos = " ) , arrow . pos
```

Listing 2: Example GlowScript Listing

`\vpythonfile[<caption>](filename)`

Typesets a file in the current directory containing VPython or GlowScript code. The listing will begin on a new page.

```
\vpythonfile[vdemo.py]{vdemo.py}
```

```
1 from __future__ import division, print_function
2 from visual import *
3
4 G = 6.7e-11
5
6 # create objects
7 giant = sphere(pos=vector(-1e11,0,0), radius=2e10, mass=2e30, color=color.red)
8 giant.p = vector(0,0,-1e4) * giant.mass
9 dwarf = sphere(pos=vector(1.5e11,0,0), radius=1e10, mass=1e30, color=color.yellow)
10 dwarf.p = -giant.p
11
12 for a in [giant, dwarf]:
13     a.orbit = curve(color=a.color, radius=2e9)
14
15 dt = 86400
16 while 1:
17     rate(100)
18     dist = dwarf.pos - giant.pos
19     force = G * giant.mass * dwarf.mass * dist / mag(dist)**3
20     giant.p = giant.p + force*dt
21     dwarf.p = dwarf.p - force*dt
22     for a in [giant, dwarf]:
23         a.pos = a.pos + a.p/a.mass * dt
24         a.orbit.append(pos=a.pos)
```

Listing 3: vdemo.py

5.17 Boxes and Environments

`\emptyanswer[<width>][<hght>]`

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

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

```
\begin{activityanswer}[\langle bgclr \rangle] [\langle frmclr \rangle] [\langle txtclr \rangle] [\langle width \rangle] [\langle hght \rangle]
  \langle environment content \rangle
\end{activityanswer}
```

Main environment for typesetting boxed answers.

```
\begin{activityanswer}
  Lorem ipsum dolor sit amet, consectetur 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, consectetur 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 width \rangle] [\langle hght \rangle]
  \langle environment content \rangle
\end{adjactivityanswer}
```

Like `\activityanswer` but adjusts vertically to tightly surround text.

```
\begin{adjactivityanswer}
  Lorem ipsum dolor sit amet, consectetur 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 consectetur. 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, consectetur 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 consectetur. Sed aliquam, nunc eget euismod ullamcorper, lectus nunc ullamcorper orci, fermentum bibendum enim nibh eget ipsum. Donec porttitor ligula eu dolor. Maecenas vitae nulla consequat libero cursus venenatis. Nam magna enim, accumsan eu, blandit sed, blandit a, eros.

`\emptybox[⟨txt⟩][⟨bgclr⟩][⟨frmclr⟩][⟨txtclr⟩][⟨width⟩][⟨hght⟩]`

Provides a fixed-size box with optional text.

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

`\adjemptybox[⟨txt⟩][⟨bgclr⟩][⟨frmclr⟩][⟨txtclr⟩][⟨width⟩][⟨hght⟩]`

Like `\emptybox` but adjusts vertically to tightly surround text.

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

`\answerbox[⟨txt⟩][⟨bgclr⟩][⟨frmclr⟩][⟨txtclr⟩][⟨width⟩][⟨hght⟩]`

Wrapper for `\emptybox`.

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

`\adjanwerbox[<txt>] [<bgclr>] [<frmclr>] [<txtclr>] [<wdth>] [<hght>]`
Wrapper for `\adjemptybox`.

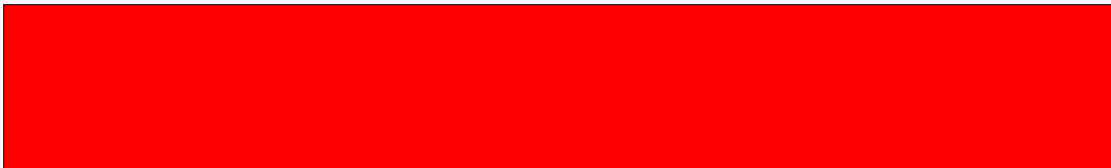
```
\adjanwerbox[Lorem ipsum dolor sit amet, consectetur adipiscing
elit. Morbi commodo, ipsum sed pharetra gravida, orci magna rhoncus
neque, id pulvinar odio lorem non turpis. Nullam sit amet enim.]
```

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

`\smallanswerbox[<txt>] [<bgclr>]`

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

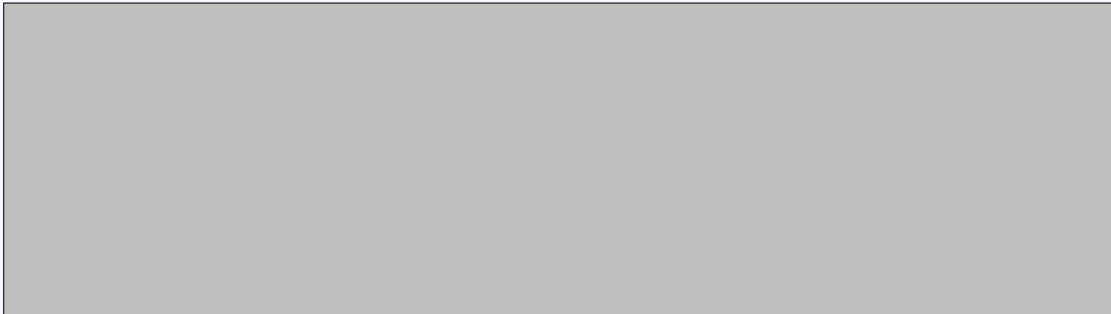
```
\smallanswerbox[] [red]
```



`\mediumanswerbox[<txt>] [<bgclr>]`

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

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



`\largeanswerbox[<txt>] [<bgclr>]`

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

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

`\largeranswerbox[⟨txt⟩][⟨bgclr⟩]`

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

```
\largeranswerbox[] [lightgray]
```

`\hugeanswerbox[⟨txt⟩][⟨bgclr⟩]`

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

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

`\hugeranswerbox[⟨txt⟩][⟨bgclr⟩]`

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

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

`\fullpageanswerbox[⟨txt⟩][⟨bgclr⟩]`

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

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

`\smallanswerform[⟨name⟩][⟨prompt⟩]`

Editable answer form with height 0.10 that of current `\textheight` and width 0.90 that of current `\linewidth`. The first argument isn't really optional, and **must** be different for each form used. Content can be typed in the box and saved with a PDF editor or viewer that supports PDF forms.

```
\smallanswerform[a1][Type your response here.]
```

`\mediumanswerform[<name>][<prompt>]`

Editable answer form with height 0.20 that of current `\textheight` and width 0.90 that of current `\linewidth`. The first argument isn't really optional, and **must** be different for each form used. Content can be typed in the box and saved with a PDF editor or viewer that supports PDF forms.

```
\mediumanswerform[a1][Type your response here.]
```

`\largeanswerform[<name>][<prompt>]`

Editable answer form with height 0.25 that of current `\textheight` and width 0.90 that of current `\linewidth` (too large to show here).

```
\largeanswerform[a1][Type your response here.]
```

`\largeranswerform[<name>][<prompt>]`

Editable answer form with height 0.33 that of current `\textheight` and width 0.90 that of current `\linewidth` (too large to show here).

```
\largeranswerform[a1][Type your response here.]
```

`\hugeanswerform[<name>][<prompt>]`

Editable answer form with height 0.50 that of current `\textheight` and width 0.90 that of current `\linewidth` (too large to show here).

```
\hugeanswerform[a1][Type your response here.]
```

`\hugeranswerform[<name>][<prompt>]`

Editable answer form with height 0.75 that of current `\textheight` and width 0.90 that of current `\linewidth` (too large to show here).

```
\hugeranswerform[a1][Type your response here.]
```

`\fullpageanswerform[<name>][<prompt>]`

Editable answer form with height 1.00 that of current `\textheight` and width 0.90 that of current `\linewidth` (too large to show here).

```
\fullpageanswerform[a1][Type your response here.]
```

`\begin{miinstructornote}`

<environment content>

`\end{miinstructornote}`

Environment for highlighting notes to instructors.

```
\begin{miinstructornote}
```

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

```
\end{miinstructornote}
```

INSTRUCTOR NOTE

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

```
\begin{mistudentnote}
  <environment content>
\end{mistudentnote}
```

Environment for highlighting notes to students.

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

STUDENT NOTE

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


```
\begin{miderivation}
  <environment content>
\end{miderivation}
```

Environment for mathematical derivations based on the `align` environment. Use `miderivation*` to suppress line numbers. See `mysolution` for how to handle long lines in this environment.

```
\begin{miderivation}
  \gamma &= \relgamma{\magvect{v}}
  && \text{given} \\
  \gamma^2 &= \oomx{\inparen{\frac{\magvect{v}}{c}}\squared}
  && \text{square both sides} \\
  \frac{1}{\gamma^2} &= 1 - \inparen{\frac{\magvect{v}}{c}}\squared
  && \text{reciprocal of both sides} \\
  \inparen{\frac{\magvect{v}}{c}}\squared &= 1 - \frac{1}{\gamma^2}
  && \text{rearrange} \\
  \frac{\magvect{v}}{c} &= \sqrt{1 - \frac{1}{\gamma^2}}
  && \text{square root of both sides}
\end{miderivation}
```

DERIVATION

$\gamma = \frac{1}{\sqrt{1 - \left(\frac{\ \vec{v}\ }{c}\right)^2}}$	given	(1)
$\gamma^2 = \frac{1}{1 - \left(\frac{\ \vec{v}\ }{c}\right)^2}$	square both sides	(2)
$\frac{1}{\gamma^2} = 1 - \left(\frac{\ \vec{v}\ }{c}\right)^2$	reciprocal of both sides	(3)
$\left(\frac{\ \vec{v}\ }{c}\right)^2 = 1 - \frac{1}{\gamma^2}$	rearrange	(4)
$\frac{\ \vec{v}\ }{c} = \sqrt{1 - \frac{1}{\gamma^2}}$	square root of both sides	(5)

```
\begin{bwinstructornote}  
  <environment content>  
\end{bwinstructornote}
```

Like `miinstructornote` but in black and grey.

```
\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, consectetur et, lacinia sit amet,  
  quam. Suspendisse wisi quam, consectetur in, blandit sed,  
  suscipit eu, eros. Etiam ligula enim, tempor ut, blandit nec,  
  mollis eu, lectus. Nam cursus. Vivamus iaculis. Aenean risus  
  purus, pharetra in, blandit quis, gravida a, turpis. Donec nisl.  
  Aenean eget mi. Fusce mattis est id diam. Phasellus faucibus  
  interdum sapien.  
\end{bwinstructornote}
```

INSTRUCTOR NOTE

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

```
\begin{bwstudentnote}
  <environment content>
\end{bwstudentnote}
```

Like mistudentnote but in black and grey.

```
\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, consectetur et, lacinia sit amet,
  quam. Suspendisse wisi quam, consectetur in, blandit sed,
  suscipit eu, eros. Etiam ligula enim, tempor ut, blandit nec,
  mollis eu, lectus. Nam cursus. Vivamus iaculis. Aenean risus
  purus, pharetra in, blandit quis, gravida a, turpis. Donec nisl.
  Aenean eget mi. Fusce mattis est id diam. Phasellus faucibus
  interdum sapien.
\end{bwstudentnote}
```

STUDENT NOTE

Nunc auctor bibendum eros. Maecenas porta accumsan mauris. Etiam enim enim, elementum sed, bibendum quis, rhoncus non, metus. Fusce neque dolor, adipiscing sed, consectetur et, lacinia sit amet, quam. Suspendisse wisi quam, consectetur 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}
```

Like `miderivation` but in black and grey. Use `bwderivation*` to suppress line numbers. See `mysolution` for how to handle long lines in this environment.

```
\begin{bwderivation}
  \gamma &= \relgamma{\magvect{v}}
  && \text{given} \\
  \gamma^2 &= \oomx{\inparen{\frac{\magvect{v}}{c}}\squared}
  && \text{square both sides} \\
  \frac{1}{\gamma^2} &= 1 - \inparen{\frac{\magvect{v}}{c}}\squared
  && \text{reciprocal of both sides} \\
  \inparen{\frac{\magvect{v}}{c}}\squared &= 1 - \frac{1}{\gamma^2}
  && \text{rearrange} \\
  \frac{\magvect{v}}{c} &= \sqrt{1 - \frac{1}{\gamma^2}}
  && \text{square root of both sides}
\end{bwderivation}
```

DERIVATION

$\gamma = \frac{1}{\sqrt{1 - \left(\frac{\ \vec{v}\ }{c}\right)^2}}$	given	(1)
$\gamma^2 = \frac{1}{1 - \left(\frac{\ \vec{v}\ }{c}\right)^2}$	square both sides	(2)
$\frac{1}{\gamma^2} = 1 - \left(\frac{\ \vec{v}\ }{c}\right)^2$	reciprocal of both sides	(3)
$\left(\frac{\ \vec{v}\ }{c}\right)^2 = 1 - \frac{1}{\gamma^2}$	rearrange	(4)
$\frac{\ \vec{v}\ }{c} = \sqrt{1 - \frac{1}{\gamma^2}}$	square root of both sides	(5)

```
\begin{mysolution}
  <environment content>
\end{mysolution}
```

Alias for simple environment for mathematical derivations based on the `align` environment. Use `mysolution*` to suppress line numbers. The second example shows how to handle long lines for this and the `derivation` environments.

```

\begin{mysolution}
\gamma &= \relgamma{\magvect{v}}
&& \text{given} \\
\gamma^2 &= \oomx{\inparen{\frac{\magvect{v}}{c}}^2}
&& \text{square both sides} \\
\frac{1}{\gamma^2} &= 1 - \inparen{\frac{\magvect{v}}{c}}^2
&& \text{reciprocal of both sides} \\
\inparen{\frac{\magvect{v}}{c}}^2 &= 1 - \frac{1}{\gamma^2}
&& \text{rearrange} \\
\frac{\magvect{v}}{c} &= \sqrt{1 - \frac{1}{\gamma^2}}
&& \text{square root of both sides}
\end{mysolution}
\begin{mysolution}
\vec{E} &= \electricfield{\mivector{1,2,3}} + \electricfield{\mivector{2,4,6}}
\nonumber \\
&\hphantom{=} \electricfield{\mivector{1,1,1}} + \electricfield{\mivector{3,5,6}}
&& \text{superposition} \\
\vec{E} &= \electricfield{\mivector{2,3,4}} + \electricfield{\mivector{2,4,6}}
\nonumber \\
&+ \electricfield{\mivector{1,1,1}} + \electricfield{\mivector{3,5,6}}
&& \text{superposition again} \\
\vec{E} &= \electricfield{\mivector{2,3,4}} + \electricfield{\mivector{2,4,6}}
\nonumber \\
&\quad + \electricfield{\mivector{1,1,1}} + \electricfield{\mivector{3,5,6}}
&& \text{more superposition}
\end{mysolution}

```

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

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

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

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

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

$$\vec{E} = \langle 1, 2, 3 \rangle N/C + \langle 2, 4, 6 \rangle N/C + \langle 3, 5, 6 \rangle N/C \quad \text{superposition} \quad (1)$$

$$\vec{E} = \langle 2, 3, 4 \rangle N/C + \langle 2, 4, 6 \rangle N/C + \langle 1, 1, 1 \rangle N/C + \langle 3, 5, 6 \rangle N/C \quad \text{superposition again} \quad (2)$$

$$\vec{E} = \langle 2, 3, 4 \rangle N/C + \langle 2, 4, 6 \rangle N/C + \langle 1, 1, 1 \rangle N/C + \langle 3, 5, 6 \rangle N/C \quad \text{more superposition} \quad (3)$$

5.18 Miscellaneous Commands

`\checkpoint`

Centered checkpoint for student discussion.

`\checkpoint`

|—— CHECKPOINT ——|

`\image{\langle imagefilename \rangle}{\langle caption \rangle}`

Centered figure displayed actual size with caption.

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

`\sneakyone{\langle thing \rangle}`

Shows argument as a sneaky one.

`\sneakyone{\frac{\langle m \rangle}{\langle m \rangle}}`

$\frac{m}{m}$

`\qed`

Command for QED symbol.

`\qed`

Q.E.D.

6 Source Code

Note the packages that must be present.

```
1 \RequirePackage{amsmath}
2 \RequirePackage{amssymb}
3 \RequirePackage{array}
4 \RequirePackage{cancel}
5 \RequirePackage[dvipsnames]{xcolor}
6 \RequirePackage{environ}
7 \RequirePackage{esint}
8 \RequirePackage[g]{esvect}
9 \RequirePackage{etoolbox}
10 \RequirePackage{filehook}
11 \RequirePackage{extarrows}
12 \RequirePackage[T1]{fontenc}
13 \RequirePackage{graphicx}
14 \RequirePackage{epstopdf}
15 \RequirePackage{textcomp}
16 \RequirePackage{letltxmacro}
17 \RequirePackage{listings}
18 \RequirePackage{mathtools}
19 \RequirePackage[framemethod=TikZ]{mdframed}
20 \RequirePackage{stackengine}
21 \RequirePackage{suffix}
22 \RequirePackage{xargs}
23 \RequirePackage{xparse}
24 \RequirePackage{xspace}
25 \RequirePackage{ifthen}
26 \RequirePackage{calligra}
27 \RequirePackage{hyperref}
28 \DeclareMathAlphabet{\mathcalligra}{T1}{calligra}{m}{n}
29 \DeclareFontShape{T1}{calligra}{m}{n}{<-s*[2.2]callig15}{}
30 \DeclareGraphicsRule{.tif}{png}{.png}{convert #1 'basename #1 .tif'.png}
31 \DeclareMathAlphabet{\mathpzc}{OT1}{pzc}{m}{it}
32 \usetikzlibrary{shadows}
33 \definecolor{vbgcolor}{rgb}{1,1,1} % background for code listings
34 \definecolor{vshadowcolor}{rgb}{0.5,0.5,0.5} % shadow for code listings
35 \lstdefinestyle{vpython}{% % style for code listings
36 language=Python,% % select language
37 morekeywords={__future__,division,append, % VPython/GlowScript specific keywords
38 arange,arrow,astuple,axis,background,black,blue,cyan,green,%
39 magenta,orange,red,white,yellow,border,box,color,comp,%
40 cone,convex,cross,curve,cylinder,degrees,diff_angle,dot,ellipsoid,extrusion,faces,%
41 font,frame,graphs,headlength,height,headwidth,helix,index,interval,label,length,%
42 line,linecolor,mag,mag2,make_trail,material,norm,normal,objects,opacity,points,pos,%
43 print,print_function,proj,pyramid,radians,radius,rate,retain,ring,rotate,scene,%
44 shaftwidth,shape,sign,size,space,sphere,text,trail_object,trail_type,True,twist,up,%
45 vector,visual,width,offset,yoffset,GlowScript,VPython,trail_color,trail_radius,%
46 pps,clear,False,CoffeeScript,graph,gdisplay,canvas,pause,vec,clone,compound,%
```

```

47 vertex,triangle,quad,attach_trail,attach_arrow,textures,bumpmaps,print_options,%
48 get_library,read_local_file},%
49 captionpos=b,% % position caption
50 frame=shadowbox,% % shadowbox around listing
51 rulesepcolor=\color{vshadowcolor},% % shadow color
52 basicstyle=\footnotesize,% % basic font for code listings
53 commentstyle=\bfseries\color{red}, % font for comments
54 keywordstyle=\bfseries\color{blue},% % font for keywords
55 showstringspaces=true,% % show spaces in strings
56 stringstyle=\bfseries\color{green},% % color for strings
57 numbers=left,% % where to put line numbers
58 numberstyle=\tiny,% % set to 'none' for no line numbers
59 xleftmargin=20pt,% % extra left margin
60 backgroundcolor=\color{vbgcolor},% % some people find this annoying
61 upquote=true,% % how to typeset quotes
62 breaklines=true}% % break long lines
63 \definecolor{formcolor}{gray}{0.90} % color for form background
64 \newcolumntype{C}[1]{>{\centering}m{#1}}
65 \newboolean{@optromanvectors}
66 \newboolean{@optboldvectors}
67 \newboolean{@optsingleabsbars}
68 \newboolean{@optbaseunits}
69 \newboolean{@optdrvdunits}
70 \newboolean{@optapproxconsts}
71 \newboolean{@optuseradians}
72 \setboolean{@optromanvectors}{false} % this is where you set the default option
73 \setboolean{@optboldvectors}{false} % this is where you set the default option
74 \setboolean{@optsingleabsbars}{false} % this is where you set the default option
75 \setboolean{@optbaseunits}{false} % this is where you set the default option
76 \setboolean{@optdrvdunits}{false} % this is where you set the default option
77 \setboolean{@optapproxconsts}{false} % this is where you set the default option
78 \setboolean{@optuseradians}{false} % this is where you set the default option
79 \DeclareOption{romanvectors}{\setboolean{@optromanvectors}{true}}
80 \DeclareOption{boldvectors}{\setboolean{@optboldvectors}{true}}
81 \DeclareOption{singleabsbars}{\setboolean{@optsingleabsbars}{true}}
82 \DeclareOption{baseunits}{\setboolean{@optbaseunits}{true}}
83 \DeclareOption{drvdunits}{\setboolean{@optdrvdunits}{true}}
84 \DeclareOption{approxconsts}{\setboolean{@optapproxconsts}{true}}
85 \DeclareOption{useradians}{\setboolean{@optuseradians}{true}}
86 \ProcessOptions\relax

87 \newcommand*{\mandiversion}{2.5.0}
88 \typeout{mandi: You're using mandi version \mandiversion.}

This block of code fixes a conflict with the amssymb package.

89 \@ifpackageloaded{amssymb}{%
90 \csundef{square}
91 \typeout{mandi: Package amssymb detected. Its \protect\square\space
92 has been redefined.}
93 }{%

```



```

94 \typeout{mandi: Package amssymb not detected.}
95 }%

```

This block of code defines unit names and symbols.

```

96 \newcommand*\per{\ensuremath{/}}
97 \newcommand*\usk{\ensuremath{\cdot}}
98 \newcommand*\unit[2]{\ensuremath{\text{\#1}\,\text{\#2}}}
99 \newcommand*\ampere{\ensuremath{\mathrm{A}}}
100 \newcommand*\arcminute{\ensuremath{'}}
101 \newcommand*\arcsecond{\ensuremath{''}}
102 \newcommand*\atomicmassunit{\ensuremath{\mathrm{u}}}
103 \newcommand*\candela{\ensuremath{\mathrm{cd}}}
104 \newcommand*\coulomb{\ensuremath{\mathrm{C}}}
105 \newcommand*\degree{\ensuremath{^\circ}}
106 \newcommand*\electronvolt{\ensuremath{\mathrm{eV}}}
107 \newcommand*\eV{\electronvolt}
108 \newcommand*\farad{\ensuremath{\mathrm{F}}}
109 \newcommand*\henry{\ensuremath{\mathrm{H}}}
110 \newcommand*\hertz{\ensuremath{\mathrm{Hz}}}
111 \newcommand*\hour{\ensuremath{\mathrm{h}}}
112 \newcommand*\joule{\ensuremath{\mathrm{J}}}
113 \newcommand*\kelvin{\ensuremath{\mathrm{K}}}
114 \newcommand*\kilogram{\ensuremath{\mathrm{kg}}}
115 \newcommand*\metre{\ensuremath{\mathrm{m}}}
116 \newcommand*\minute{\ensuremath{\mathrm{min}}}
117 \newcommand*\mole{\ensuremath{\mathrm{mol}}}
118 \newcommand*\newton{\ensuremath{\mathrm{N}}}
119 \newcommand*\ohm{\ensuremath{\Omega}}
120 \newcommand*\pascal{\ensuremath{\mathrm{Pa}}}
121 \newcommand*\radian{\ensuremath{\mathrm{rad}}}
122 \newcommand*\second{\ensuremath{\mathrm{s}}}
123 \newcommand*\siemens{\ensuremath{\mathrm{S}}}
124 \newcommand*\steradian{\ensuremath{\mathrm{sr}}}
125 \newcommand*\tesla{\ensuremath{\mathrm{T}}}
126 \newcommand*\volt{\ensuremath{\mathrm{V}}}
127 \newcommand*\watt{\ensuremath{\mathrm{W}}}
128 \newcommand*\weber{\ensuremath{\mathrm{Wb}}}
129 \newcommand*\C{\coulomb}
130 \newcommand*\F{\farad}
131 %\H is already defined as a LaTeX accent
132 \newcommand*\J{\joule}
133 \newcommand*\N{\newton}
134 \newcommand*\Pa{\pascal}
135 \newcommand*\rad{\radian}
136 \newcommand*\sr{\steradian}
137 %\S is already defined as a LaTeX symbol
138 \newcommand*\T{\tesla}
139 \newcommand*\V{\volt}
140 \newcommand*\W{\watt}
141 \newcommand*\Wb{\weber}

```

```

142 \newcommand*\square[1]{\ensuremath{#1^2}} % prefix 2
143 \newcommand*\cubic[1]{\ensuremath{#1^3}} % prefix 3
144 \newcommand*\quartic[1]{\ensuremath{#1^4}} % prefix 4
145 \newcommand*\reciprocal[1]{\ensuremath{#1^{-1}}} % prefix -1
146 \newcommand*\reciprocalsquare[1]{\ensuremath{#1^{-2}}} % prefix -2
147 \newcommand*\reciprocalcubic[1]{\ensuremath{#1^{-3}}} % prefix -3
148 \newcommand*\reciprocalquartic[1]{\ensuremath{#1^{-4}}} % prefix -4
149 \newcommand*\squared{\ensuremath{^2}} % postfix 2
150 \newcommand*\cubed{\ensuremath{^3}} % postfix 3
151 \newcommand*\quarted{\ensuremath{^4}} % postfix 4
152 \newcommand*\reciprocaled{\ensuremath{^{-1}}} % postfix -1
153 \newcommand*\reciprocalsquared{\ensuremath{^{-2}}} % postfix -2
154 \newcommand*\reciprocalcubed{\ensuremath{^{-3}}} % postfix -3
155 \newcommand*\reciprocalquarted{\ensuremath{^{-4}}} % postfix -4

```

Define a new named physics quantity or physical constant and commands for selecting units. My thanks to Ulrich Diez for contributing this code.

```

156 \newcommand*\mi@exchangeargs[2]{#2#1}%
157 \newcommand*\mi@name{}%
158 \long\def\mi@name#1#{\romannumeral0\mi@innername{#1}}%
159 \newcommand*\mi@innername[2]{%
160   \expandafter\mi@exchangeargs\expandafter{\csname#2\endcsname}{#1}}%
161 \begingroup
162 \@firstofone{%
163   \endgroup
164   \newcommand*\mi@forkifnull[3]{%
165     \romannumeral\iffalse{\fi\expandafter\@secondoftwo\expandafter%
166       {\expandafter{\string#1}\expandafter\@secondoftwo\string}%
167       \expandafter\@firstoftwo\expandafter{\iffalse}\fi0 #3}{0 #2}}}%
168 \newcommand*\selectbaseunit[3]{#1}
169 \newcommand*\selectdrvdunit[3]{#2}
170 \newcommand*\selecttradunit[3]{#3}
171 \newcommand*\selectunit{}
172 \newcommand*\perpusebaseunit{\let\selectunit=\selectbaseunit}
173 \newcommand*\perpusedrvdunit{\let\selectunit=\selectdrvdunit}
174 \newcommand*\perpusetradunit{\let\selectunit=\selecttradunit}
175 \newcommand*\hereusebaseunit[1]{%
176   \begingroup\perpusebaseunit#1\endgroup}%
177 \newcommand*\hereusedrvdunit[1]{%
178   \begingroup\perpusedrvdunit#1\endgroup}%
179 \newcommand*\hereusetradunit[1]{%
180   \begingroup\perpusetradunit#1\endgroup}%
181 \newenvironment{usebaseunit}{\perpusebaseunit}{}%
182 \newenvironment{usedrvdunit}{\perpusedrvdunit}{}%
183 \newenvironment{usetradunit}{\perpusetradunit}{}%
184 \newcommand*\newphysicsquantity{\definephysicsquantity{\newcommand}}
185 \newcommand*\redefinephysicsquantity{\definephysicsquantity{\renewcommand}}
186 \newcommandx*\definephysicsquantity[5][4=,5=]{%
187   \innerdefinewhatsoeverquantityfork{#3}{#4}{#5}{#1}{#2}{-}{[1]}{##1}}%
188 \newcommand*\newphysicsconstant{\definephysicsconstant{\newcommand}}

```

```

189 \newcommand*\redefinephysicsconstant{\definephysicsconstant{\renewcommand}}
190 \newcommandx*\definephysicsconstant[7][6=,7=]{%
191   \innerdefinewhatsoeverquantityfork{#5}{#6}{#7}{#1}{#2}{#3}{#4}}%
192 \newcommand*\innerdefinewhatsoeverquantityfork[3]{%
193   \expandafter\innerdefinewhatsoeverquantity\romannumeral0%
194   \mi@forkifnull{#3}{\mi@forkifnull{#2}{#1}{#2}{#1}}%
195   {\mi@forkifnull{#2}{#1}{#2}{#3}{#1}}%
196 \newcommand*\innerdefinewhatsoeverquantity[8]{%
197   \mi@name#4{#5}#7{\unit{#8}{\selectunit{#3}{#1}{#2}}}%
198   \mi@name#4{#5baseunit}#7{\unit{#8}{#3}}%
199   \mi@name#4{#5drvdunit}#7{\unit{#8}{#1}}%
200   \mi@name#4{#5tradunit}#7{\unit{#8}{#2}}%
201   \mi@name#4{#5onlyunit}{\selectunit{#3}{#1}{#2}}%
202   \mi@name#4{#5onlybaseunit}{\ensuremath{#3}}%
203   \mi@name#4{#5onlydrvdunit}{\ensuremath{#1}}%
204   \mi@name#4{#5onlytradunit}{\ensuremath{#2}}%
205   \mi@name#4{#5value}#7{\ensuremath{#8}}%
206   \mi@forkifnull{#7}{%
207     \ifx#4\renewcommand\mi@name\let{#5mathsymbol}=\relax\fi
208     \mi@name\newcommand*{#5mathsymbol}{\ensuremath{#6}}}{}}%

```

This block of code processes the options.

```

209 \ifthenelse{\boolean{@optboldvectors}}
210   {\typeout{mandi: You'll get bold vectors.}}
211   {\ifthenelse{\boolean{@optromanvectors}}
212     {\typeout{mandi: You'll get Roman vectors.}}
213     {\typeout{mandi: You'll get italic vectors.}}}
214 \ifthenelse{\boolean{@optsingleabsbars}}
215   {\typeout{mandi: You'll get single absolute value bars.}}
216   {\typeout{mandi: You'll get double absolute value bars.}}
217 \ifthenelse{\boolean{@optbaseunits}}
218   {\perpusebaseunit %
219   \typeout{mandi: You'll get base units.}}
220   {\ifthenelse{\boolean{@optdrvdunits}}
221     {\perpusedrvdunit %
222     \typeout{mandi: You'll get derived units.}}
223     {\perpusetradunit %
224     \typeout{mandi: You'll get traditional units.}}}
225 \ifthenelse{\boolean{@optapproxconsts}}
226   {\typeout{mandi: You'll get approximate constants.}}
227   {\typeout{mandi: You'll get precise constants.}}
228 \ifthenelse{\boolean{@optuseradians}}
229   {\typeout{mandi: You'll get radians in ang mom, ang impulse, and torque.}}
230   {\typeout{mandi: You won't get radians in ang mom, ang impulse, and torque.}}

```

This is a utility command for picking constants.

```

231 \ifthenelse{\boolean{@optapproxconsts}}
232   {\newcommand*\mi@p}[2]{#1} % approximate value
233   {\newcommand*\mi@p}[2]{#2} % precise value

```

SI base unit of length or spatial displacement

234 `\newcommand*\m{\metre}`

SI base unit of mass

235 `\newcommand*\kg{\kilogram}`

SI base unit of time or temporal displacement

236 `\newcommand*\s{\second}`

SI base unit of electric current

237 `\newcommand*\A{\ampere}`

SI base unit of thermodynamic temperature

238 `\newcommand*\K{\kelvin}`

SI base unit of amount

239 `\newcommand*\mol{\mole}`

SI base unit of luminous intensity

240 `\newcommand*\cd{\candela}`

241 `\newcommand*\dimdisplacement{\ensuremath{\mathrm{L}}}`

242 `\newcommand*\dimmass{\ensuremath{\mathrm{M}}}`

243 `\newcommand*\dimduration{\ensuremath{\mathrm{T}}}`

244 `\newcommand*\dimcurrent{\ensuremath{\mathrm{I}}}`

245 `\newcommand*\dimtemperature{\ensuremath{\mathrm{\Theta}}}`

246 `\newcommand*\dimamount{\ensuremath{\mathrm{N}}}`

247 `\newcommand*\dimluminous{\ensuremath{\mathrm{J}}}`

248 `\newcommand*\indegrees[1]{\unit{#1}{\degree}}`

249 `\newcommand*\inFahrenheit[1]{\unit{#1}{\degree\mathrm{F}}}`

250 `\newcommand*\inCelsius[1]{\unit{#1}{\degree\mathrm{C}}}`

251 `\newcommand*\inarcminutes[1]{\unit{#1}{\arcminute}}`

252 `\newcommand*\inarcseconds[1]{\unit{#1}{\arcsecond}}`

253 `\newcommand*\ineV[1]{\unit{#1}{\electronvolt}}`

254 `\newcommand*\ineVocs[1]{\unit{#1}{\mathrm{eV}\per c^2}}`

255 `\newcommand*\ineVoc[1]{\unit{#1}{\mathrm{eV}\per c}}`

256 `\newcommand*\inMeV[1]{\unit{#1}{\mathrm{MeV}}}`

257 `\newcommand*\inMeVocs[1]{\unit{#1}{\mathrm{MeV}\per c^2}}`

258 `\newcommand*\inMeVoc[1]{\unit{#1}{\mathrm{MeV}\per c}}`

259 `\newcommand*\inGeV[1]{\unit{#1}{\mathrm{GeV}}}`

260 `\newcommand*\inGeVocs[1]{\unit{#1}{\mathrm{GeV}\per c^2}}`

261 `\newcommand*\inGeVoc[1]{\unit{#1}{\mathrm{GeV}\per c}}`

262 `\newcommand*\inamu[1]{\unit{#1}{\mathrm{u}}}`

263 `\newcommand*\ingram[1]{\unit{#1}{\mathrm{g}}}`

264 `\newcommand*\ingrampercubiccm[1]{\unit{#1}{\mathrm{g}\per\cubic\mathrm{cm}}}`

```

265 \newcommand*\inAU[1]{\unit{#1}{\mathrm{AU}}}
266 \newcommand*\inly[1]{\unit{#1}{\mathrm{ly}}}
267 \newcommand*\incyr[1]{\unit{#1}{c\usk\mathrm{year}}}
268 \newcommand*\inpc[1]{\unit{#1}{\mathrm{pc}}}
269 \newcommand*\insolarL[1]{\unit{#1}{\Lsolar}}
270 \newcommand*\insolarT[1]{\unit{#1}{\Tsolar}}
271 \newcommand*\insolarR[1]{\unit{#1}{\Rsolar}}
272 \newcommand*\insolarM[1]{\unit{#1}{\Msolar}}
273 \newcommand*\insolarF[1]{\unit{#1}{\Fsolar}}
274 \newcommand*\insolarf[1]{\unit{#1}{\fsolar}}
275 \newcommand*\insolarMag[1]{\unit{#1}{\Magsolar}}
276 \newcommand*\insolarmag[1]{\unit{#1}{\magsolar}}
277 \newcommand*\insolarD[1]{\unit{#1}{\Dsolar}}
278 \newcommand*\insolard[1]{\unit{#1}{\dsolar}}
279 \newcommand*\velocityc[1]{\ensuremath{#1c}}
280 \newcommand*\lorentz[1]{\ensuremath{#1}}
281 \newcommand*\speed{\velocity}
282 \newphysicsquantity{displacement}%
283   {\m}%
284   [\m]%
285   [\m]
286 \newphysicsquantity{mass}%
287   {\kg}%
288   [\kg]%
289   [\kg]
290 \newphysicsquantity{duration}%
291   {\s}%
292   [\s]%
293   [\s]
294 \newphysicsquantity{current}%
295   {\A}%
296   [\A]%
297   [\A]
298 \newphysicsquantity{temperature}%
299   {\K}%
300   [\K]%
301   [\K]
302 \newphysicsquantity{amount}%
303   {\mol}%
304   [\mol]%
305   [\mol]
306 \newphysicsquantity{luminous}%
307   {\cd}%
308   [\cd]%
309   [\cd]
310 \newphysicsquantity{planeangle}%
311   {\m\usk\reciprocal\m}%
312   [\rad]%
313   []
314 \newphysicsquantity{solidangle}%

```

315 $\{\text{m}\text{ squared}\text{ usk}\text{ reciprocalsquare}\text{ m}\}\%$
 316 $[\text{sr}]%$
 317 $[\]$
 318 $\text{newphysicsquantity}\{\text{velocity}\}\%$
 319 $\{\text{m}\text{ usk}\text{ reciprocal}\text{ s}\}\%$
 320 $[\text{m}\text{ usk}\text{ reciprocal}\text{ s}]%$
 321 $[\text{m}\text{ per}\text{ s}]$
 322 $\text{newphysicsquantity}\{\text{acceleration}\}\%$
 323 $\{\text{m}\text{ usk}\text{ s}\text{ reciprocalsquared}\}\%$
 324 $[\text{N}\text{ per}\text{ kg}]%$
 325 $[\text{m}\text{ per}\text{ s}\text{ squared}]$
 326 $\text{newphysicsquantity}\{\text{gravitationalfield}\}\%$
 327 $\{\text{m}\text{ usk}\text{ s}\text{ reciprocalsquared}\}\%$
 328 $[\text{N}\text{ per}\text{ kg}]%$
 329 $[\text{N}\text{ per}\text{ kg}]$
 330 $\text{newphysicsquantity}\{\text{gravitationalpotential}\}\%$
 331 $\{\text{square}\text{ m}\text{ usk}\text{ reciprocalsquare}\text{ s}\}\%$
 332 $[\text{J}\text{ per}\text{ kg}]%$
 333 $[\text{J}\text{ per}\text{ kg}]$
 334 $\text{newphysicsquantity}\{\text{momentum}\}\%$
 335 $\{\text{m}\text{ usk}\text{ kg}\text{ usk}\text{ reciprocal}\text{ s}\}\%$
 336 $[\text{N}\text{ usk}\text{ s}]%$
 337 $[\text{kg}\text{ usk}\text{ m}\text{ per}\text{ s}]$
 338 $\text{newphysicsquantity}\{\text{impulse}\}\%$
 339 $\{\text{m}\text{ usk}\text{ kg}\text{ usk}\text{ reciprocal}\text{ s}\}\%$
 340 $[\text{N}\text{ usk}\text{ s}]%$
 341 $[\text{N}\text{ usk}\text{ s}]$
 342 $\text{newphysicsquantity}\{\text{force}\}\%$
 343 $\{\text{m}\text{ usk}\text{ kg}\text{ usk}\text{ s}\text{ reciprocalsquared}\}\%$
 344 $[\text{N}]%$
 345 $[\text{N}]$
 346 $\text{newphysicsquantity}\{\text{springstiffness}\}\%$
 347 $\{\text{kg}\text{ usk}\text{ s}\text{ reciprocalsquared}\}\%$
 348 $[\text{N}\text{ per}\text{ m}]%$
 349 $[\text{N}\text{ per}\text{ m}]$
 350 $\text{newphysicsquantity}\{\text{springstretch}\}\%$
 351 $\{\text{m}\}\%$
 352 $[\]%$
 353 $[\]$
 354 $\text{newphysicsquantity}\{\text{area}\}\%$
 355 $\{\text{m}\text{ squared}\}\%$
 356 $[\]%$
 357 $[\]$
 358 $\text{newphysicsquantity}\{\text{volume}\}\%$
 359 $\{\text{cubic}\text{ m}\}\%$
 360 $[\]%$
 361 $[\]$
 362 $\text{newphysicsquantity}\{\text{linearmassdensity}\}\%$
 363 $\{\text{reciprocal}\text{ m}\text{ usk}\text{ kg}\}\%$
 364 $[\text{kg}\text{ per}\text{ m}]%$

365 $[\text{kg}\text{per}\text{m}]$
 366 $\backslash\text{newphysicsquantity}\{\text{areamassdensity}\}\%$
 367 $\{\text{m}\backslash\text{reciprocal}\text{squared}\backslash\text{usk}\backslash\text{kg}\}\%$
 368 $[\text{kg}\text{per}\text{m}\text{squared}]\%$
 369 $[\text{kg}\text{per}\text{m}\text{squared}]$
 370 $\backslash\text{newphysicsquantity}\{\text{volumemassdensity}\}\%$
 371 $\{\text{m}\backslash\text{reciprocal}\text{cubed}\backslash\text{usk}\backslash\text{kg}\}\%$
 372 $[\text{kg}\text{per}\text{m}\text{cubed}]\%$
 373 $[\text{kg}\text{per}\text{m}\text{cubed}]$
 374 $\backslash\text{newphysicsquantity}\{\text{youngsmodulus}\}\%$
 375 $\{\text{reciprocal}\text{m}\backslash\text{usk}\backslash\text{kg}\backslash\text{usk}\backslash\text{s}\backslash\text{reciprocal}\text{squared}\}\%$
 376 $[\text{N}\text{per}\text{m}\text{squared}]\%$
 377 $[\text{Pa}]$
 378 $\backslash\text{newphysicsquantity}\{\text{stress}\}\%$
 379 $\{\text{reciprocal}\text{m}\backslash\text{usk}\backslash\text{kg}\backslash\text{usk}\backslash\text{s}\backslash\text{reciprocal}\text{squared}\}\%$
 380 $[\text{N}\text{per}\text{m}\text{squared}]\%$
 381 $[\text{Pa}]$
 382 $\backslash\text{newphysicsquantity}\{\text{pressure}\}\%$
 383 $\{\text{reciprocal}\text{m}\backslash\text{usk}\backslash\text{kg}\backslash\text{usk}\backslash\text{s}\backslash\text{reciprocal}\text{squared}\}\%$
 384 $[\text{N}\text{per}\text{m}\text{squared}]\%$
 385 $[\text{Pa}]$
 386 $\backslash\text{newphysicsquantity}\{\text{strain}\}\%$
 387 $\{\}\%$
 388 $[\]\%$
 389 $[\]$
 390 $\backslash\text{newphysicsquantity}\{\text{work}\}\%$
 391 $\{\text{m}\text{squared}\backslash\text{usk}\backslash\text{kg}\backslash\text{usk}\backslash\text{s}\backslash\text{reciprocal}\text{squared}\}\%$
 392 $[\text{N}\text{usk}\text{m}]\%$
 393 $[\text{J}]$
 394 $\backslash\text{newphysicsquantity}\{\text{energy}\}\%$
 395 $\{\text{m}\text{squared}\backslash\text{usk}\backslash\text{kg}\backslash\text{usk}\backslash\text{s}\backslash\text{reciprocal}\text{squared}\}\%$
 396 $[\text{N}\text{usk}\text{m}]\%$
 397 $[\text{J}]$
 398 $\backslash\text{newphysicsquantity}\{\text{power}\}\%$
 399 $\{\text{m}\text{squared}\backslash\text{usk}\backslash\text{kg}\backslash\text{usk}\backslash\text{s}\backslash\text{reciprocal}\text{cubed}\}\%$
 400 $[\text{J}\text{per}\text{s}]\%$
 401 $[\text{W}]$
 402 $\backslash\text{newphysicsquantity}\{\text{specificheatcapacity}\}\%$
 403 $\{\text{J}\text{per}\text{K}\backslash\text{usk}\backslash\text{kg}\}\%$
 404 $[\text{J}\text{per}\text{K}\backslash\text{usk}\backslash\text{kg}]\%$
 405 $[\text{J}\text{per}\text{K}\backslash\text{usk}\backslash\text{kg}]$
 406 $\backslash\text{newphysicsquantity}\{\text{angularvelocity}\}\%$
 407 $\{\text{rad}\backslash\text{usk}\backslash\text{reciprocal}\text{s}\}\%$
 408 $[\text{rad}\text{per}\text{s}]\%$
 409 $[\text{rad}\text{per}\text{s}]$
 410 $\backslash\text{newphysicsquantity}\{\text{angularacceleration}\}\%$
 411 $\{\text{rad}\backslash\text{usk}\backslash\text{s}\backslash\text{reciprocal}\text{squared}\}\%$
 412 $[\text{rad}\text{per}\text{s}\text{squared}]\%$
 413 $[\text{rad}\text{per}\text{s}\text{squared}]$
 414 $\backslash\text{newphysicsquantity}\{\text{momentofinertia}\}\%$

```

415 {\m\squared\usk\kg}%
416 [\m\usk\kg\squared]%
417 [\J\usk\s\squared]
418 \ifthenelse{\boolean{@optuseradians}}
419 {%
420 \newphysicsquantity{angularmomentum}%
421   {\m\squared\usk\kg\usk\reciprocal\s\usk\reciprocal\rad}%
422   [\N\usk\m\usk\s\per\rad]%
423   [\m\squared\usk\kg\usk\reciprocal\s\usk\reciprocal\rad]
424 \newphysicsquantity{angularimpulse}%
425   {\m\squared\usk\kg\usk\reciprocal\s\usk\reciprocal\rad}%
426   [\N\usk\m\usk\s\per\rad]%
427   [\J\usk\s\per\rad]
428 \newphysicsquantity{torque}%
429   {\m\squared\usk\kg\usk\s\reciprocal\squared\usk\reciprocal\rad}%
430   [\N\usk\m\per\rad]%
431   [\J\per\rad]
432 }%
433 {%
434 \newphysicsquantity{angularmomentum}%
435   {\m\squared\usk\kg\usk\reciprocal\s}%
436   [\N\usk\m\usk\s]%
437   [\m\squared\usk\kg\usk\reciprocal\s]
438 \newphysicsquantity{angularimpulse}%
439   {\m\squared\usk\kg\usk\reciprocal\s}%
440   [\N\usk\m\usk\s]%
441   [\J\usk\s]
442 \newphysicsquantity{torque}%
443   {\m\squared\usk\kg\usk\s\reciprocal\squared}%
444   [\N\usk\m]%
445   [\J]
446 }%
447 \newphysicsquantity{entropy}%
448   {\m\squared\usk\kg\usk\s\reciprocal\squared\usk\reciprocal\K}%
449   [\J\per\K]%
450   [\J\per\K]
451 \newphysicsquantity{wavelength}%
452   {\m}%
453   [\m]%
454   [\m]
455 \newphysicsquantity{wavenumber}%
456   {\reciprocal\m}%
457   [\per\m]%
458   [\per\m]
459 \newphysicsquantity{frequency}%
460   {\reciprocal\s}%
461   [\hertz]%
462   [\hertz]
463 \newphysicsquantity{angularfrequency}%
464   {\rad\usk\reciprocal\s}%

```


465 $[\text{rad}\text{per}\text{s}]$ %
466 $[\text{rad}\text{per}\text{s}]$
467 $\text{newphysicsquantity}\{\text{charge}\}$ %
468 $\{\text{A}\text{usk}\text{s}\}$ %
469 $[\text{C}]$ %
470 $[\text{C}]$
471 $\text{newphysicsquantity}\{\text{permittivity}\}$ %
472 $\{\text{m}\text{reciprocalcubed}\text{usk}\text{reciprocal}\text{kg}\text{usk}\text{s}\text{reciprocalquarted}\text{usk}\text{A}\text{quared}\}$ %
473 $[\text{F}\text{per}\text{m}]$ %
474 $[\text{C}\text{quared}\text{per}\text{N}\text{usk}\text{m}\text{quared}]$
475 $\text{newphysicsquantity}\{\text{permeability}\}$ %
476 $\{\text{m}\text{usk}\text{kg}\text{usk}\text{s}\text{reciprocalquared}\text{usk}\text{A}\text{reciprocalquared}\}$ %
477 $[\text{henry}\text{per}\text{m}]$ %
478 $[\text{T}\text{usk}\text{m}\text{per}\text{A}]$
479 $\text{newphysicsquantity}\{\text{electricfield}\}$ %
480 $\{\text{m}\text{usk}\text{kg}\text{usk}\text{s}\text{reciprocalcubed}\text{usk}\text{reciprocal}\text{A}\}$ %
481 $[\text{V}\text{per}\text{m}]$ %
482 $[\text{N}\text{per}\text{C}]$
483 $\text{newphysicsquantity}\{\text{electricdipolemoment}\}$ %
484 $\{\text{m}\text{usk}\text{s}\text{usk}\text{A}\}$ %
485 $[\text{C}\text{usk}\text{m}]$ %
486 $[\text{C}\text{usk}\text{m}]$
487 $\text{newphysicsquantity}\{\text{electricflux}\}$ %
488 $\{\text{m}\text{cubed}\text{usk}\text{kg}\text{usk}\text{s}\text{reciprocalcubed}\text{usk}\text{reciprocal}\text{A}\}$ %
489 $[\text{V}\text{usk}\text{m}]$ %
490 $[\text{N}\text{usk}\text{m}\text{quared}\text{per}\text{C}]$
491 $\text{newphysicsquantity}\{\text{magneticfield}\}$ %
492 $\{\text{kg}\text{usk}\text{s}\text{reciprocalquared}\text{usk}\text{reciprocal}\text{A}\}$ %
493 $[\text{T}]$ %
494 $[\text{N}\text{per}\text{C}\text{usk}(\text{m}\text{per}\text{s})]$ % also $\text{Wb}\text{per}\text{m}\text{quared}$
495 $\text{newphysicsquantity}\{\text{magneticflux}\}$ %
496 $\{\text{m}\text{quared}\text{usk}\text{kg}\text{usk}\text{s}\text{reciprocalquared}\text{usk}\text{reciprocal}\text{A}\}$ %
497 $[\text{volt}\text{usk}\text{s}]$ %
498 $[\text{T}\text{usk}\text{m}\text{quared}]$ % also Wb and $\text{J}\text{per}\text{A}$
499 $\text{newphysicsquantity}\{\text{cmagneticfield}\}$ %
500 $\{\text{m}\text{usk}\text{kg}\text{usk}\text{s}\text{reciprocalcubed}\text{usk}\text{reciprocal}\text{A}\}$ %
501 $[\text{V}\text{per}\text{m}]$ %
502 $[\text{N}\text{per}\text{C}]$
503 $\text{newphysicsquantity}\{\text{linearchargedensity}\}$ %
504 $\{\text{reciprocal}\text{m}\text{usk}\text{s}\text{usk}\text{A}\}$ %
505 $[\text{C}\text{per}\text{m}]$ %
506 $[\text{C}\text{per}\text{m}]$
507 $\text{newphysicsquantity}\{\text{areachargedensity}\}$ %
508 $\{\text{reciprocalsquare}\text{m}\text{usk}\text{s}\text{usk}\text{A}\}$ %
509 $[\text{C}\text{per}\text{square}\text{m}]$ %
510 $[\text{C}\text{per}\text{square}\text{m}]$
511 $\text{newphysicsquantity}\{\text{volumechargedensity}\}$ %
512 $\{\text{reciprocalcubic}\text{m}\text{usk}\text{s}\text{usk}\text{A}\}$ %
513 $[\text{C}\text{per}\text{cubic}\text{m}]$ %
514 $[\text{C}\text{per}\text{cubic}\text{m}]$

515 \newphysicsquantity{mobility}%
516 {\m\squared\usk\kg\usk\s\reciprocalquarted\usk\reciprocal\A}%
517 [\m\squared\per\volt\usk\s]%
518 [(\m\per\s)\per(N\per\C)]
519 \newphysicsquantity{numberdensity}%
520 {\reciprocalcubic\m}%
521 [\per\cubic\m]%
522 [\per\cubic\m]
523 \newphysicsquantity{polarizability}%
524 {\reciprocal\kg\usk\s\quarted\usk\usquare\A}%
525 [\C\usk\square\m\per\V]%
526 [\C\usk\m\per(N\per\C)]
527 \newphysicsquantity{electricpotential}%
528 {\square\m\usk\kg\usk\reciprocalcubic\s\usk\reciprocal\A}%
529 [\J\per\C]%
530 [\V]
531 \newphysicsquantity{emf}%
532 {\square\m\usk\kg\usk\reciprocalcubic\s\usk\reciprocal\A}%
533 [\J\per\C]%
534 [\V]
535 \newphysicsquantity{dielectricconstant}%
536 {}%
537 []%
538 []
539 \newphysicsquantity{indexofrefraction}%
540 {}%
541 []%
542 []
543 \newphysicsquantity{relativepermittivity}%
544 {}%
545 []%
546 []
547 \newphysicsquantity{relativepermeability}%
548 {}%
549 []%
550 []
551 \newphysicsquantity{energydensity}%
552 {\m\reciprocaled\usk\kg\usk\reciprocalsquare\s}%
553 [\J\per\cubic\m]%
554 [\J\per\cubic\m]
555 \newphysicsquantity{energyflux}%
556 {\kg\usk\s\reciprocalcubed}%
557 [\W\per\m\squared]%
558 [\W\per\m\squared]
559 \newphysicsquantity{electroncurrent}%
560 {\reciprocal\s}%
561 [\ensuremath{\mathrm{e}}\per\s]%
562 [\ensuremath{\mathrm{e}}\per\s]
563 \newphysicsquantity{conventionalcurrent}%
564 {\A}%

```

565 [\C\per\s]%
566 [\A]
567 \newphysicsquantity{magneticdipolemoment}%
568 {\square\m\usk\A}%
569 [\J\per\T]%
570 [\A\usk\square\m]
571 \newphysicsquantity{currentdensity}%
572 {\reciprocal\square\m\usk\A}%
573 [\C\usk\s\per\square\m]%
574 [\A\per\square\m]
575 \newphysicsquantity{capacitance}%
576 {\reciprocal\square\m\usk\reciprocal\kg\usk\quartic\s\usk\square\A}%
577 [F]%
578 [\C\per\V] % also \C\squared\per\N\usk\m, \s\per\ohm
579 \newphysicsquantity{inductance}%
580 {\square\m\usk\kg\usk\reciprocal\square\s\usk\reciprocal\square\A}%
581 [henry]%
582 [\volt\usk\s\per\A] % also \square\m\usk\kg\per\C\squared, \Wb\per\A
583 \newphysicsquantity{conductivity}%
584 {\reciprocal\cubic\m\usk\reciprocal\kg\usk\cubic\s\usk\square\A}%
585 [siemens\per\m]%
586 [(\A\per\square\m)\per(\V\per\m)]
587 \newphysicsquantity{resistivity}%
588 {\cubic\m\usk\kg\usk\reciprocal\cubic\s\usk\reciprocal\square\A}%
589 [\ohm\usk\m]%
590 [(\V\per\m)\per(\A\per\square\m)]
591 \newphysicsquantity{resistance}%
592 {\square\m\usk\kg\usk\reciprocal\cubic\s\usk\reciprocal\square\A}%
593 [\V\per\A]%
594 [\ohm]
595 \newphysicsquantity{conductance}%
596 {\reciprocal\square\m\usk\reciprocal\kg\usk\cubic\s\usk\square\A}%
597 [\A\per\V]%
598 [\siemens]
599 \newphysicsquantity{magneticcharge}%
600 {\m\usk\A}%
601 [\m\usk\A]%
602 [\m\usk\A]
603 \newcommand*{\lv}{\ensuremath{\left\langle}}
604 \newcommand*{\rv}{\ensuremath{\right\rangle}}
605 \ExplSyntaxOn % Written in LaTeX3
606 \NewDocumentCommand{\magvectncomps}{ m O{} }
607 {%
608   \sum_of_squares:nn { #1 }{ #2 }
609 }%
610 \cs_new:Npn \sum_of_squares:nn #1 #2
611 {%
612   \tl_if_empty:nTF { #2 }
613     {%
614       \clist_set:Nn \l_tmpa_clist { #1 }

```

```

615     \ensuremath{%
616       \sqrt{\left(\clist_use:Nnnn \l_tmpa_clist { \right)^2+\left( } { \right)^2+
617       \left( } { \right)^2+\left( } \right)^2 }
618     }%
619   }%
620   {%
621     \clist_set:Nn \l_tmpa_clist { #1 }
622     \ensuremath{%
623       \sqrt{\left(\clist_use:Nnnn \l_tmpa_clist {\;{ #2 }\right)^2+\left(} {\;
624       { #2 }\right)^2+\left(} {\;{ #2 }\right)^2+\left(} {\;{ #2 }\right)^2}
625     }%
626   }%
627 }%
628 \ExplSyntaxOff
629 %
630 \newcommand*\zerovect{\vect{0}}
631 \newcommand*\ncompszerovect{\mivector{0,0,0}}
632 \ifthenelse{\boolean{@optboldvectors}}
633   {\newcommand*\vect}[1]{\ensuremath{\boldsymbol{#1}}}
634   {\ifthenelse{\boolean{@optromanvectors}}
635     {\newcommand*\vect}[1]{\ensuremath{\vv{\mathrm{#1}}}}
636     {\newcommand*\vect}[1]{\ensuremath{\vv{#1}}}}
637 \ifthenelse{\boolean{@optsingleabsbars}}
638   {\newcommand*\magvect}[1]{\ensuremath{\abs{\vect{#1}}}}
639   {\newcommand*\magvect}[1]{\ensuremath{\magof{\vect{#1}}}}
640 \newcommand*\magsquaredvect[1]{\ensuremath{\magvect{#1}\squared}}
641 \newcommand*\magnvect[2]{\ensuremath{\magvect{#1}^{#2}}}
642 \newcommand*\dmagvect[1]{\ensuremath{\dx{\magvect{#1}}}}
643 \newcommand*\Dmagvect[1]{\ensuremath{\Delta!\magvect{#1}}}
644 \ifthenelse{\boolean{@optboldvectors}}
645   {\newcommand*\dirvect}[1]{\ensuremath{\widehat{\boldsymbol{#1}}}}
646   {\ifthenelse{\boolean{@optromanvectors}}
647     {\newcommand*\dirvect}[1]{\ensuremath{\widehat{\mathrm{#1}}}}
648     {\newcommand*\dirvect}[1]{\ensuremath{\widehat{#1}}}}
649 \newcommand*\direction{\dirvect}
650 \newcommand*\componentalong[2]{\ensuremath{\mathrm{comp}_{#1}{#2}}}
651 \newcommand*\expcomponentalong[2]{\ensuremath{\frac{\vectdotvect{#2}{#1}}
652 {\magof{#1}}}}
653 \newcommand*\ucomponentalong[2]{\ensuremath{\vectdotvect{#2}{#1}}}
654 \newcommand*\projectiononto[2]{\ensuremath{\mathrm{proj}_{#1}{#2}}}
655 \newcommand*\expprojectiononto[2]{\ensuremath{%
656   \inparen{\frac{\vectdotvect{#2}{#1}}{\magof{#1}}}\frac{#1}{\magof{#1}}}}
657 \newcommand*\uprojectiononto[2]{\ensuremath{%
658   \inparen{\vectdotvect{#2}{#1}}#1}}
659 \ifthenelse{\boolean{@optromanvectors}}
660   {\newcommand*\compvect}[2]{\ensuremath{\ssub{\mathrm{#1}}{\ (#2)}}}
661   {\newcommand*\compvect}[2]{\ensuremath{\ssub{#1}{\ (#2)}}}
662 \newcommand*\scompsvect[1]{\ensuremath{\lv%
663   \compvect{#1}{x},%
664   \compvect{#1}{y},%

```

```

665 \compvect{#1}{z}\rv}}
666 \newcommand*\scompsdirvect[1]{\ensuremath{\lv%
667 \compvect{\widehat{#1}}{x},%
668 \compvect{\widehat{#1}}{y},%
669 \compvect{\widehat{#1}}{z}\rv}}
670 \ifthenelse{\boolean{@optromanvectors}}
671 {\newcommand*\compdirvect[2]{\ensuremath{%
672 \ssub{\widehat{\mathrm{#1}}}{(\#2)}}}
673 {\newcommand*\compdirvect[2]{\ensuremath{%
674 \ssub{\widehat{#1}}{(\#2)}}}
675 \newcommand*\magvectscomps[1]{\ensuremath{\sqrt{%
676 \compvect{#1}{x}\squared +%
677 \compvect{#1}{y}\squared +%
678 \compvect{#1}{z}\squared}}}
679 \newcommand*\dvect[1]{\ensuremath{\mathrm{d}\vect{#1}}}
680 \newcommand*\Dvect[1]{\ensuremath{\Delta\vect{#1}}}
681 \newcommand*\dirvect[1]{\ensuremath{\widehat{\dvect{#1}}}}
682 \newcommand*\dirDvect[1]{\ensuremath{\widehat{Dvect{#1}}}}
683 \newcommand*\ddirvect[1]{\ensuremath{\mathrm{d}\dirvect{#1}}}
684 \newcommand*\ddirection{\ddirvect}
685 \newcommand*\Ddirvect[1]{\ensuremath{\Delta\dirvect{#1}}}
686 \newcommand*\Ddirection{\Ddirvect}
687 \ifthenelse{\boolean{@optsingleabsbars}}
688 {\newcommand*\magdvect[1]{\ensuremath{\abs{\dvect{#1}}}}
689 \newcommand*\magDvect[1]{\ensuremath{\abs{Dvect{#1}}}}
690 {\newcommand*\magdvect[1]{\ensuremath{\magof{\dvect{#1}}}}
691 \newcommand*\magDvect[1]{\ensuremath{\magof{Dvect{#1}}}}
692 \newcommand*\compdvect[2]{\ensuremath{\mathrm{d}\compvect{#1}{#2}}}
693 \newcommand*\compDvect[2]{\ensuremath{\Delta\compvect{#1}{#2}}}
694 \newcommand*\scompsdvect[1]{\ensuremath{\lv%
695 \compdvect{#1}{x},%
696 \compdvect{#1}{y},%
697 \compdvect{#1}{z}\rv}}
698 \newcommand*\scompsDvect[1]{\ensuremath{\lv%
699 \compDvect{#1}{x},%
700 \compDvect{#1}{y},%
701 \compDvect{#1}{z}\rv}}
702 \newcommand*\dervect[2]{\ensuremath{\frac{\dvect{#1}}{\mathrm{d}{#2}}}}
703 \newcommand*\Dervect[2]{\ensuremath{\frac{Dvect{#1}}{\Delta{#2}}}}
704 \newcommand*\compdervect[3]{\ensuremath{\dbyd{\compvect{#1}{#2}}{#3}}}
705 \newcommand*\compDervect[3]{\ensuremath{\DbyD{\compvect{#1}{#2}}{#3}}}
706 \newcommand*\scompsdervect[2]{\ensuremath{\lv%
707 \compdervect{#1}{x}{#2},%
708 \compdervect{#1}{y}{#2},%
709 \compdervect{#1}{z}{#2}\rv}}
710 \newcommand*\scompsDervect[2]{\ensuremath{\lv%
711 \compDervect{#1}{x}{#2},%
712 \compDervect{#1}{y}{#2},%
713 \compDervect{#1}{z}{#2}\rv}}
714 \ifthenelse{\boolean{@optsingleabsbars}}

```

```

715 {\newcommand*\magdervect}[2]{\ensuremath{\abs{\dervect{#1}{#2}}}}
716 \newcommand*\magDervect}[2]{\ensuremath{\abs{\Dervect{#1}{#2}}}}
717 {\newcommand*\magdervect}[2]{\ensuremath{\magof{\dervect{#1}{#2}}}}
718 \newcommand*\magDervect}[2]{\ensuremath{\magof{\Dervect{#1}{#2}}}}
719 \newcommand*\dermagvect}[2]{\ensuremath{\dbyd{\magvect{#1}{#2}}}}
720 \newcommand*\Dermagvect}[2]{\ensuremath{\DbyD{\magvect{#1}{#2}}}}
721 \newcommand*\derdirvect}[2]{\ensuremath{\dbyd{\dirvect{#1}{#2}}}}
722 \newcommand*\derdirection}{\derdirvect}
723 \newcommand*\Derdirvect}[2]{\ensuremath{\DbyD{\dirvect{#1}{#2}}}}
724 \newcommand*\Derdirection}{\Derdirvect}
725 \ifthenelse{\boolean{@optboldvectors}}
726 {\newcommand*\vectsub}[2]{\ensuremath{\boldsymbol{#1}_{\text{\tiny{#2}}}}}
727 {\ifthenelse{\boolean{@optromanvectors}}
728 {\newcommand*\vectsub}[2]{\ensuremath{\mathbf{#1}_{\text{\tiny{#2}}}}}
729 {\newcommand*\vectsub}[2]{\ensuremath{\mathbf{#1}_{\text{\tiny{#2}}}}}
730 \ifthenelse{\boolean{@optromanvectors}}
731 {\newcommand*\compvectsub}[3]{\ensuremath{\ssub{\mathbf{#1}}{#2},\(#3\)}}
732 {\newcommand*\compvectsub}[3]{\ensuremath{\ssub{#1}{#2},\(#3\)}}
733 \newcommand*\scompvectsub}[2]{\ensuremath{\lv%
734 \compvectsub{#1}{#2}{x},%
735 \compvectsub{#1}{#2}{y},%
736 \compvectsub{#1}{#2}{z}\rv}}
737 \ifthenelse{\boolean{@optsingleabsbars}}
738 {\newcommand*\magvectsub}[2]{\ensuremath{\abs{\vectsub{#1}{#2}}}}
739 {\newcommand*\magvectsub}[2]{\ensuremath{\magof{\vectsub{#1}{#2}}}}
740 \newcommand*\magsquaredvectsub}[2]{\ensuremath{\magvectsub{#1}{#2}\squared}}
741 \newcommand*\magnvectsub}[3]{\ensuremath{\magvectsub{#1}{#2}^{#3}}}
742 \newcommand*\magvectsubscmps}[2]{\ensuremath{\sqrt{%
743 \compvectsub{#1}{#2}{x}\squared +%
744 \compvectsub{#1}{#2}{y}\squared +%
745 \compvectsub{#1}{#2}{z}\squared}}}
746 \ifthenelse{\boolean{@optromanvectors}}
747 {\newcommand*\dirvectsub}[2]{\ensuremath{\ssub{\widehat{\mathbf{#1}}}{#2}}}
748 {\newcommand*\dirvectsub}[2]{\ensuremath{\ssub{\widehat{#1}}{#2}}}
749 \newcommand*\directionsub}{\dirvectsub}
750 \newcommand*\dvectsub}[2]{\ensuremath{\mathbf{d}\vectsub{#1}{#2}}}
751 \newcommand*\Dvectsub}[2]{\ensuremath{\Delta\vectsub{#1}{#2}}}
752 \newcommand*\compdvectsub}[3]{\ensuremath{\mathbf{d}\compvectsub{#1}{#2}{#3}}}
753 \newcommand*\compDvectsub}[3]{\ensuremath{\Delta\compvectsub{#1}{#2}{#3}}}
754 \newcommand*\scompdvectsub}[2]{\ensuremath{\lv%
755 \compdvectsub{#1}{#2}{x},%
756 \compdvectsub{#1}{#2}{y},%
757 \compdvectsub{#1}{#2}{z}\rv}}
758 \newcommand*\scompDvectsub}[2]{\ensuremath{\lv%
759 \compDvectsub{#1}{#2}{x},%
760 \compDvectsub{#1}{#2}{y},%
761 \compDvectsub{#1}{#2}{z}\rv}}
762 \newcommand*\dermagvectsub}[3]{\ensuremath{\dbyd{\magvectsub{#1}{#2}}{#3}}}
763 \newcommand*\Dermagvectsub}[3]{\ensuremath{\DbyD{\magvectsub{#1}{#2}}{#3}}}
764 \newcommand*\dervectsub}[3]{\ensuremath{\dbyd{\vectsub{#1}{#2}}{#3}}}

```

```

765 \newcommand*\Dervectsub}[3]{\ensuremath{\DbyD{\vectsub{#1}{#2}{#3}}}
766 \ifthenelse{\boolean{@optsingleabsbars}}
767   {\newcommand*\magdervectsub}[3]{\ensuremath{\abs{\dervectsub{#1}{#2}{#3}}}}
768   \newcommand*\magDervectsub}[3]{\ensuremath{\abs{\Dervectsub{#1}{#2}{#3}}}}
769   {\newcommand*\magdervectsub}[3]{\ensuremath{\magof{\dervectsub{#1}{#2}{#3}}}}
770   \newcommand*\magDervectsub}[3]{\ensuremath{\magof{\Dervectsub{#1}{#2}{#3}}}}
771 \newcommand*\compdervectsub}[4]{\ensuremath{\dbyd{\compvectsub{#1}{#2}{#3}{#4}}}
772 \newcommand*\compDervectsub}[4]{\ensuremath{\DbyD{\compvectsub{#1}{#2}{#3}{#4}}}
773 \newcommand*\scompsdervectsub}[3]{\ensuremath{\lv%
774   \compdervectsub{#1}{#2}{x}{#3},%
775   \compdervectsub{#1}{#2}{y}{#3},%
776   \compdervectsub{#1}{#2}{z}{#3}\rv}}
777 \newcommand*\scompsDervectsub}[3]{\ensuremath{\lv%
778   \compDervectsub{#1}{#2}{x}{#3},%
779   \compDervectsub{#1}{#2}{y}{#3},%
780   \compDervectsub{#1}{#2}{z}{#3}\rv}}
781 \newcommand*\vectdotvect}[2]{\ensuremath{#1}\bullet{#2}}
782 \newcommand*\vectdotsvect}[2]{\ensuremath{\scompsvect{#1}\bullet\scompsvect{#2}}}
783 \newcommand*\vectdotevect}[2]{\ensuremath{%
784   \compvect{#1}{x}\compvect{#2}{x}+%
785   \compvect{#1}{y}\compvect{#2}{y}+%
786   \compvect{#1}{z}\compvect{#2}{z}}}
787 \newcommand*\vectdotsdvect}[2]{\ensuremath{\scompsvect{#1}\bullet\scompsdvect{#2}}}
788 \newcommand*\vectdotsDvect}[2]{\ensuremath{\scompsvect{#1}\bullet\scompsDvect{#2}}}
789 \newcommand*\vectdotedvect}[2]{\ensuremath{%
790   \compvect{#1}{x}\compdvect{#2}{x}+%
791   \compvect{#1}{y}\compdvect{#2}{y}+%
792   \compvect{#1}{z}\compdvect{#2}{z}}}
793 \newcommand*\vectdoteDvect}[2]{\ensuremath{%
794   \compvect{#1}{x}\compDvect{#2}{x}+%
795   \compvect{#1}{y}\compDvect{#2}{y}+%
796   \compvect{#1}{z}\compDvect{#2}{z}}}
797 \newcommand*\vectsubdotsvectsub}[4]{\ensuremath{%
798   \scompsvectsub{#1}{#2}\bullet\scompsvectsub{#3}{#4}}}
799 \newcommand*\vectsubdotevectsub}[4]{\ensuremath{%
800   \compvectsub{#1}{#2}{x}\compvectsub{#3}{#4}{x}+%
801   \compvectsub{#1}{#2}{y}\compvectsub{#3}{#4}{y}+%
802   \compvectsub{#1}{#2}{z}\compvectsub{#3}{#4}{z}}}
803 \newcommand*\vectsubdotsdvectsub}[4]{\ensuremath{%
804   \scompsvectsub{#1}{#2}\bullet\scompsdvectsub{#3}{#4}}}
805 \newcommand*\vectsubdotsDvectsub}[4]{\ensuremath{%
806   \scompsvectsub{#1}{#2}\bullet\scompsDvectsub{#3}{#4}}}
807 \newcommand*\vectsubdotedvectsub}[4]{\ensuremath{%
808   \compvectsub{#1}{#2}{x}\compdvectsub{#3}{#4}{x}+%
809   \compvectsub{#1}{#2}{y}\compdvectsub{#3}{#4}{y}+%
810   \compvectsub{#1}{#2}{z}\compdvectsub{#3}{#4}{z}}}
811 \newcommand*\vectsubdoteDvectsub}[4]{\ensuremath{%
812   \compvectsub{#1}{#2}{x}\compDvectsub{#3}{#4}{x}+%
813   \compvectsub{#1}{#2}{y}\compDvectsub{#3}{#4}{y}+%
814   \compvectsub{#1}{#2}{z}\compDvectsub{#3}{#4}{z}}}

```

```

815 \newcommand*\vectsubdotsdvect}[3]{\ensuremath{%
816 \scompsvectsub{#1}{#2}\bullet\scompsdvect{#3}}}
817 \newcommand*\vectsubdotsDvect}[3]{\ensuremath{%
818 \scompsvectsub{#1}{#2}\bullet\scompsDvect{#3}}}
819 \newcommand*\vectsubdotedvect}[3]{\ensuremath{%
820 \compvectsub{#1}{#2}{x}\compdvect{#3}{x}+%
821 \compvectsub{#1}{#2}{y}\compdvect{#3}{y}+%
822 \compvectsub{#1}{#2}{z}\compdvect{#3}{z}}}
823 \newcommand*\vectsubdoteDvect}[3]{\ensuremath{%
824 \compvectsub{#1}{#2}{x}\compDvect{#3}{x}+%
825 \compvectsub{#1}{#2}{y}\compDvect{#3}{y}+%
826 \compvectsub{#1}{#2}{z}\compDvect{#3}{z}}}
827 \newcommand*\dervectdotsvect}[3]{\ensuremath{%
828 \scompsdervect{#1}{#2}\bullet\scompsvect{#3}}}
829 \newcommand*\Dervectdotsvect}[3]{\ensuremath{%
830 \scompsDervect{#1}{#2}\bullet\scompsvect{#3}}}
831 \newcommand*\dervectdotevect}[3]{\ensuremath{%
832 \compdervect{#1}{x}{#2}\compvect{#3}{x}+%
833 \compdervect{#1}{y}{#2}\compvect{#3}{y}+%
834 \compdervect{#1}{z}{#2}\compvect{#3}{z}}}
835 \newcommand*\Dervectdotevect}[3]{\ensuremath{%
836 \compDervect{#1}{x}{#2}\compvect{#3}{x}+%
837 \compDervect{#1}{y}{#2}\compvect{#3}{y}+%
838 \compDervect{#1}{z}{#2}\compvect{#3}{z}}}
839 \newcommand*\vectdotsdervect}[3]{\ensuremath{%
840 \scompsvect{#1}\bullet\scompsdervect{#2}{#3}}}
841 \newcommand*\vectdotsDervect}[3]{\ensuremath{%
842 \scompsvect{#1}\bullet\scompsDervect{#2}{#3}}}
843 \newcommand*\vectdotedervect}[3]{\ensuremath{%
844 \compvect{#1}{x}\compdervect{#2}{x}{#3}+%
845 \compvect{#1}{y}\compdervect{#2}{y}{#3}+%
846 \compvect{#1}{z}\compdervect{#2}{z}{#3}}}
847 \newcommand*\vectdoteDervect}[3]{\ensuremath{%
848 \compvect{#1}{x}\compDervect{#2}{x}{#3}+%
849 \compvect{#1}{y}\compDervect{#2}{y}{#3}+%
850 \compvect{#1}{z}\compDervect{#2}{z}{#3}}}
851 \newcommand*\dervectdotsdvect}[3]{\ensuremath{%
852 \scompsdervect{#1}{#2}\bullet\scompsdvect{#3}}}
853 \newcommand*\DervectdotsDvect}[3]{\ensuremath{%
854 \scompsDervect{#1}{#2}\bullet\scompsDvect{#3}}}
855 \newcommand*\dervectdotedvect}[3]{\ensuremath{%
856 \compdervect{#1}{x}{#2}\compdvect{#3}{x}+%
857 \compdervect{#1}{y}{#2}\compdvect{#3}{y}+%
858 \compdervect{#1}{z}{#2}\compdvect{#3}{z}}}
859 \newcommand*\DervectdoteDvect}[3]{\ensuremath{%
860 \compDervect{#1}{x}{#2}\compDvect{#3}{x}+%
861 \compDervect{#1}{y}{#2}\compDvect{#3}{y}+%
862 \compDervect{#1}{z}{#2}\compDvect{#3}{z}}}
863 \newcommand*\vectcrossvect}[2]{\ensuremath{%
864 {#1}\boldsymbol{\times}{#2}}}

```



```

865 \newcommand*\ltriplecross}[3]{\ensuremath{%
866 \inparen{#1}\boldsymbol{\times}{#2}\boldsymbol{\times}{#3}}
867 \newcommand*\rtriplecross}[3]{\ensuremath{#1}\boldsymbol{\times}%
868 \inparen{#2}\boldsymbol{\times}{#3}}}
869 \newcommand*\ltriplescalar}[3]{\ensuremath{%
870 #1}\boldsymbol{\times}{#2}\bullet{#3}}
871 \newcommand*\rtriplescalar}[3]{\ensuremath{%
872 #1}\bullet{#2}\boldsymbol{\times}{#3}}
873 \newcommand*\ezero{\ensuremath{\boldsymbol{e}_0}}
874 \newcommand*\eone{\ensuremath{\boldsymbol{e}_1}}
875 \newcommand*\etwo{\ensuremath{\boldsymbol{e}_2}}
876 \newcommand*\ethree{\ensuremath{\boldsymbol{e}_3}}
877 \newcommand*\efour{\ensuremath{\boldsymbol{e}_4}}
878 \newcommand*\ek}[1]{\ensuremath{\boldsymbol{e}_{#1}}}
879 \newcommand*\e{\ek}
880 \newcommand*\uezero{\ensuremath{\widehat{\boldsymbol{e}}_0}}
881 \newcommand*\ueone{\ensuremath{\widehat{\boldsymbol{e}}_1}}
882 \newcommand*\uetwo{\ensuremath{\widehat{\boldsymbol{e}}_2}}
883 \newcommand*\uethree{\ensuremath{\widehat{\boldsymbol{e}}_3}}
884 \newcommand*\uefour{\ensuremath{\widehat{\boldsymbol{e}}_4}}
885 \newcommand*\uek}[1]{\ensuremath{\widehat{\boldsymbol{e}}_{#1}}}
886 \newcommand*\ue{\uek}
887 \newcommand*\ezerozero{\ek{00}}
888 \newcommand*\ezeroone{\ek{01}}
889 \newcommand*\ezerotwo{\ek{02}}
890 \newcommand*\ezerothree{\ek{03}}
891 \newcommand*\ezerofour{\ek{04}}
892 \newcommand*\eoneone{\ek{11}}
893 \newcommand*\eonetwo{\ek{12}}
894 \newcommand*\eonethree{\ek{13}}
895 \newcommand*\eonefour{\ek{14}}
896 \newcommand*\etwoone{\ek{21}}
897 \newcommand*\etwotwo{\ek{22}}
898 \newcommand*\etwothree{\ek{23}}
899 \newcommand*\etwofour{\ek{24}}
900 \newcommand*\ethreeone{\ek{31}}
901 \newcommand*\ethreetwo{\ek{32}}
902 \newcommand*\ethreethree{\ek{33}}
903 \newcommand*\ethreefour{\ek{34}}
904 \newcommand*\efourone{\ek{41}}
905 \newcommand*\efourtwo{\ek{42}}
906 \newcommand*\efourthree{\ek{43}}
907 \newcommand*\efourfour{\ek{44}}
908 \newcommand*\euzero{\ensuremath{\boldsymbol{e}^0}}
909 \newcommand*\euone{\ensuremath{\boldsymbol{e}^1}}
910 \newcommand*\eutwo{\ensuremath{\boldsymbol{e}^2}}
911 \newcommand*\euthree{\ensuremath{\boldsymbol{e}^3}}
912 \newcommand*\eufour{\ensuremath{\boldsymbol{e}^4}}
913 \newcommand*\euk}[1]{\ensuremath{\boldsymbol{e}^{#1}}}
914 \newcommand*\eu{\euk}

```

```

915 \newcommand*\ueuzero{\ensuremath{\widehat{\boldsymbol{e}}^0}}
916 \newcommand*\ueuone{\ensuremath{\widehat{\boldsymbol{e}}^1}}
917 \newcommand*\ueutwo{\ensuremath{\widehat{\boldsymbol{e}}^2}}
918 \newcommand*\ueuthree{\ensuremath{\widehat{\boldsymbol{e}}^3}}
919 \newcommand*\ueufour{\ensuremath{\widehat{\boldsymbol{e}}^4}}
920 \newcommand*\ueuk[1]{\ensuremath{\widehat{\boldsymbol{e}}^{\#1}}}
921 \newcommand*\ueu{\ueuk}
922 \newcommand*\euzerozero{\euk{00}}
923 \newcommand*\euzeroone{\euk{01}}
924 \newcommand*\euzerotwo{\euk{02}}
925 \newcommand*\euzerothree{\euk{03}}
926 \newcommand*\euzerofour{\euk{04}}
927 \newcommand*\euoneone{\euk{11}}
928 \newcommand*\euonetwo{\euk{12}}
929 \newcommand*\euonethree{\euk{13}}
930 \newcommand*\euonefour{\euk{14}}
931 \newcommand*\eutwoone{\euk{21}}
932 \newcommand*\eutwotwo{\euk{22}}
933 \newcommand*\eutwothree{\euk{23}}
934 \newcommand*\eutwofour{\euk{24}}
935 \newcommand*\euthreeone{\euk{31}}
936 \newcommand*\euthreetwo{\euk{32}}
937 \newcommand*\euthreethree{\euk{33}}
938 \newcommand*\euthreefour{\euk{34}}
939 \newcommand*\eufourone{\euk{41}}
940 \newcommand*\eufourtwo{\euk{42}}
941 \newcommand*\eufourthree{\euk{43}}
942 \newcommand*\eufourfour{\euk{44}}
943 \newcommand*\gzero{\ensuremath{\boldsymbol{\gamma}_0}}
944 \newcommand*\gone{\ensuremath{\boldsymbol{\gamma}_1}}
945 \newcommand*\gtwo{\ensuremath{\boldsymbol{\gamma}_2}}
946 \newcommand*\gthree{\ensuremath{\boldsymbol{\gamma}_3}}
947 \newcommand*\gfour{\ensuremath{\boldsymbol{\gamma}_4}}
948 \newcommand*\gk[1]{\ensuremath{\boldsymbol{\gamma}_{\#1}}}
949 \newcommand*\g{\gk}
950 \newcommand*\gzerozero{\gk{00}}
951 \newcommand*\gzeroone{\gk{01}}
952 \newcommand*\gzerotwo{\gk{02}}
953 \newcommand*\gzerothree{\gk{03}}
954 \newcommand*\gzerofour{\gk{04}}
955 \newcommand*\goneone{\gk{11}}
956 \newcommand*\gonetwo{\gk{12}}
957 \newcommand*\gonethree{\gk{13}}
958 \newcommand*\gonefour{\gk{14}}
959 \newcommand*\gtwoone{\gk{21}}
960 \newcommand*\gtwotwo{\gk{22}}
961 \newcommand*\gtwothree{\gk{23}}
962 \newcommand*\gtwofour{\gk{24}}
963 \newcommand*\gthreeone{\gk{31}}
964 \newcommand*\gthreetwo{\gk{32}}

```

```

965 \newcommand*\gthreethree{\gk{33}}
966 \newcommand*\gthreefour{\gk{34}}
967 \newcommand*\gfourone{\gk{41}}
968 \newcommand*\gfourtwo{\gk{42}}
969 \newcommand*\gfourthree{\gk{43}}
970 \newcommand*\gfourfour{\gk{44}}
971 \newcommand*\guzero{\ensuremath{\boldsymbol{\gamma}^0}}
972 \newcommand*\guone{\ensuremath{\boldsymbol{\gamma}^1}}
973 \newcommand*\gutwo{\ensuremath{\boldsymbol{\gamma}^2}}
974 \newcommand*\guthree{\ensuremath{\boldsymbol{\gamma}^3}}
975 \newcommand*\gufour{\ensuremath{\boldsymbol{\gamma}^4}}
976 \newcommand*\guk[1]{\ensuremath{\boldsymbol{\gamma}^{\#1}}}
977 \newcommand*\gu{\guk}
978 \newcommand*\guzerozero{\guk{00}}
979 \newcommand*\guzeroone{\guk{01}}
980 \newcommand*\guzerotwo{\guk{02}}
981 \newcommand*\guzerothree{\guk{03}}
982 \newcommand*\guzerofour{\guk{04}}
983 \newcommand*\guoneone{\guk{11}}
984 \newcommand*\guonetwo{\guk{12}}
985 \newcommand*\guonethree{\guk{13}}
986 \newcommand*\guonefour{\guk{14}}
987 \newcommand*\gutwoone{\guk{21}}
988 \newcommand*\gutwotwo{\guk{22}}
989 \newcommand*\gutwothree{\guk{23}}
990 \newcommand*\gutwofour{\guk{24}}
991 \newcommand*\guthreeone{\guk{31}}
992 \newcommand*\guthreetwo{\guk{32}}
993 \newcommand*\guthreethree{\guk{33}}
994 \newcommand*\guthreefour{\guk{34}}
995 \newcommand*\gufourone{\guk{41}}
996 \newcommand*\gufourtwo{\guk{42}}
997 \newcommand*\gufourthree{\guk{43}}
998 \newcommand*\gufourfour{\guk{44}}
999 \ExplSyntaxOn % Vectors formatted as in M&I, written in LaTeX3
1000 \NewDocumentCommand{\mivector}{ O{,} m o }%
1001 {%
1002   \mi_vector:nn { #1 } { #2 }
1003   \IfValueT{#3}{\;{#3}}
1004 }%
1005 \seq_new:N \l__mi_list_seq
1006 \cs_new_protected:Npn \mi_vector:nn #1 #2
1007 {%
1008   \ensuremath{%
1009     \seq_set_split:Nnn \l__mi_list_seq { , } { #2 }
1010     \int_compare:nF { \seq_count:N \l__mi_list_seq = 1 } { \left\langle }
1011     \seq_use:Nnnn \l__mi_list_seq { #1 } { #1 } { #1 }
1012     \int_compare:nF { \seq_count:N \l__mi_list_seq = 1 } { \right\rangle }
1013   }%
1014 }%

```

```

1015 \ExplSyntaxOff
1016 \ExplSyntaxOn % Column and row vectors, written in LaTeX3
1017 \seq_new:N \l__vector_arg_seq
1018 \cs_new_protected:Npn \vector_main:nmmm #1 #2 #3 #4
1019 {%
1020   \seq_set_split:Nnn \l__vector_arg_seq { #3 } { #4 }
1021   \begin{#1matrix}
1022     \seq_use:Nmmm \l__vector_arg_seq { #2 } { #2 } { #2 }
1023   \end{#1matrix}
1024 }%
1025 \NewDocumentCommand{\rowvector}{0{,} m }
1026 {%
1027   \ensuremath{
1028     \vector_main:nmmm { p } { \, \, } { #1 } { #2 }
1029   }%
1030 }%
1031 \NewDocumentCommand{\colvector}{0{,} m }
1032 {%
1033   \ensuremath{
1034     \vector_main:nmmm { p } { \ } { #1 } { #2 }
1035   }%
1036 }%
1037 \ExplSyntaxOff
1038 \newcommandx{\scompscvect}[2][1,usedefault]{%
1039   \ifthenelse{\equal{#1}{}}%
1040   {%
1041     \colvector{\msub{#2}{1},\msub{#2}{2},\msub{#2}{3}}%
1042   }%
1043   {%
1044     \colvector{\msub{#2}{0},\msub{#2}{1},\msub{#2}{2},\msub{#2}{3}}%
1045   }%
1046 }%
1047 \newcommandx{\scompscvect}[2][1,usedefault]{%
1048   \ifthenelse{\equal{#1}{}}%
1049   {%
1050     \colvector{\msup{#2}{1},\msup{#2}{2},\msup{#2}{3}}%
1051   }%
1052   {%
1053     \colvector{\msup{#2}{0},\msup{#2}{1},\msup{#2}{2},\msup{#2}{3}}%
1054   }%
1055 }%
1056 \newcommandx{\scompsrvect}[2][1,usedefault]{%
1057   \ifthenelse{\equal{#1}{}}%
1058   {%
1059     \rowvector[,]{\msub{#2}{1},\msub{#2}{2},\msub{#2}{3}}%
1060   }%
1061   {%
1062     \rowvector[,]{\msub{#2}{0},\msub{#2}{1},\msub{#2}{2},\msub{#2}{3}}%
1063   }%
1064 }%

```

```

1065 \newcommandx{\scompsRvect}[2][1,usedefault]{%
1066   \ifthenelse{\equal{#1}{}}%
1067   {%
1068     \rowvector[,]{\msup{#2}{1},\msup{#2}{2},\msup{#2}{3}}%
1069   }%
1070   {%
1071     \rowvector[,]{\msup{#2}{0},\msup{#2}{1},\msup{#2}{2},\msup{#2}{3}}%
1072   }%
1073 }%
1074 \newcommand*{\bra}[1]{\ensuremath{\left\langle\!#1\right\lvert}}
1075 \newcommand*{\ket}[1]{\ensuremath{\left\lvert\!#1\right\rangle}}
1076 \newcommand*{\bracket}[2]{\ensuremath{\left\langle\!#1\!\!\right.}}
1077   \left\lvert\!#2\right\rangle}}
1078 \newphysicsconstant{oofpez}%
1079   {\ensuremath{\frac{1}{\phantom{o}_4\pi\epsilon_0}}}%
1080   {\mi@p{9}{8.9876}\timestento{9}}%
1081   {\m\cubed\usk\kg\usk\reciprocalquartic\s\usk\A\reciprocalquared}%
1082   [\m\per\farad]%
1083   [\newton\usk\m\squared\per\coulomb\squared]
1084 \newphysicsconstant{oofpezcs}%
1085   {\ensuremath{\frac{1}{\phantom{o}_4\pi\epsilon_0 c^2\phantom{o}}}}%
1086   {\tento{-7}}%
1087   {\m\usk\kg\usk\s\reciprocalquared\usk\A\reciprocalquared}%
1088   [T\usk\m\squared]%
1089   [N\usk\s\squared\per\C\squared]
1090 \newphysicsconstant{vacuumpermittivity}%
1091   {\ensuremath{\epsilon_0}}%
1092   {\mi@p{9.0}{8.8542}\timestento{-12}}%
1093   {\m\reciprocalcubed\usk\reciprocal\kg\usk\s\quarted\usk\A\squared}%
1094   [F\per\m]%
1095   [C\squared\per\N\usk\m\squared]
1096 \newphysicsconstant{mzofp}%
1097   {\ensuremath{\frac{\phantom{o}\mu_0\phantom{o}}{4\pi}}}%
1098   {\tento{-7}}%
1099   {\m\usk\kg\usk\s\reciprocalquared\usk\A\reciprocalquared}%
1100   [\henry\per\m]%
1101   [tesla\usk\m\per\A]
1102 \newphysicsconstant{vacuumpermeability}%
1103   {\ensuremath{\mu_0}}%
1104   {4\pi\timestento{-7}}%
1105   {\m\usk\kg\usk\s\reciprocalquared\usk\A\reciprocalquared}%
1106   [\henry\per\m]%
1107   [T\usk\m\per\A]
1108 \newphysicsconstant{boltzmann}%
1109   {\ensuremath{k_B}}%
1110   {\mi@p{1.4}{1.3806}\timestento{-23}}%
1111   {\m\squared\usk\kg\usk\reciprocalsquare\s\usk\reciprocal\K}%
1112   [\joule\per\K]%
1113   [J\per\K]
1114 \newphysicsconstant{boltzmannineV}%

```

1115 $\{\ensurermath{k_B}\}$ %
1116 $\{\mi@p{8.6}\{8.6173\}\timestento{-5}\}$ %
1117 $\{\eV\usk\reciprocal\K\}$ %
1118 $[\eV\per\K]$ %
1119 $[\eV\per\K]$
1120 $\newphysicsconstant\{stefanboltzmann\}$ %
1121 $\{\ensurermath{\sigma}\}$ %
1122 $\{\mi@p{5.7}\{5.6704\}\timestento{-8}\}$ %
1123 $\{\kg\usk\reciprocalcubed\usk\K\reciprocalquarted\}$ %
1124 $[\W\per\m\squared\usk\K^4]$ %
1125 $[\W\per\m\squared\usk\K\quarted]$
1126 $\newphysicsconstant\{planck\}$ %
1127 $\{\ensurermath{h}\}$ %
1128 $\{\mi@p{6.6}\{6.6261\}\timestento{-34}\}$ %
1129 $\{\m\squared\usk\kg\usk\reciprocal\s\}$ %
1130 $[\J\usk\s]$ %
1131 $[\J\usk\s]$
1132 $\newphysicsconstant\{planckineV\}$ %
1133 $\{\ensurermath{h}\}$ %
1134 $\{\mi@p{4.1}\{4.1357\}\timestento{-15}\}$ %
1135 $\{\eV\usk\s\}$ %
1136 $[\eV\usk\s]$ %
1137 $[\eV\usk\s]$
1138 $\newphysicsconstant\{planckbar\}$ %
1139 $\{\ensurermath{\hslash}\}$ %
1140 $\{\mi@p{1.1}\{1.0546\}\timestento{-34}\}$ %
1141 $\{\m\squared\usk\kg\usk\reciprocal\s\}$ %
1142 $[\J\usk\s]$ %
1143 $[\J\usk\s]$
1144 $\newphysicsconstant\{planckbarineV\}$ %
1145 $\{\ensurermath{\hslash}\}$ %
1146 $\{\mi@p{6.6}\{6.5821\}\timestento{-16}\}$ %
1147 $\{\eV\usk\s\}$ %
1148 $[\eV\usk\s]$ %
1149 $[\eV\usk\s]$
1150 $\newphysicsconstant\{planckc\}$ %
1151 $\{\ensurermath{hc}\}$ %
1152 $\{\mi@p{2.0}\{1.9864\}\timestento{-25}\}$ %
1153 $\{\m\cubed\usk\kg\usk\reciprocalsquare\s\}$ %
1154 $[\J\usk\m]$ %
1155 $[\J\usk\m]$
1156 $\newphysicsconstant\{planckcineV\}$ %
1157 $\{\ensurermath{hc}\}$ %
1158 $\{\mi@p{2.0}\{1.9864\}\timestento{-25}\}$ %
1159 $\{\eV\usk\text{n}\m\}$ %
1160 $[\eV\usk\text{n}\m]$ %
1161 $[\eV\usk\text{n}\m]$
1162 $\newphysicsconstant\{rydberg\}$ %
1163 $\{\ensurermath{\msub{R}{\infty}}\}$ %
1164 $\{\mi@p{1.1}\{1.0974\}\timestento{7}\}$ %

1165 $\{\backslash\text{reciprocal}\backslash\text{m}\}$ %
1166 $[\backslash\text{reciprocal}\backslash\text{m}]$ %
1167 $[\backslash\text{reciprocal}\backslash\text{m}]$
1168 $\backslash\text{newphysicsconstant}\{\text{bohrradius}\}$ %
1169 $\{\backslash\text{ensuremath}\{a_0\}\}$ %
1170 $\{\backslash\text{mi}\@p\{5.3\}\{5.2918\}\backslash\text{timestento}\{-11\}\}$ %
1171 $\{\backslash\text{m}\}$ %
1172 $[\backslash\text{m}]$ %
1173 $[\backslash\text{m}]$
1174 $\backslash\text{newphysicsconstant}\{\text{finestructure}\}$ %
1175 $\{\backslash\text{ensuremath}\{\backslash\alpha\}\}$ %
1176 $\{\backslash\text{mi}\@p\{\backslash\text{frac}\{1\}\{137\}\}\{7.2974\}\backslash\text{timestento}\{-3\}\}$ %
1177 $\{\}$ %
1178 $[\]$ %
1179 $[\]$
1180 $\backslash\text{newphysicsconstant}\{\text{avogadro}\}$ %
1181 $\{\backslash\text{ensuremath}\{N_A\}\}$ %
1182 $\{\backslash\text{mi}\@p\{6.0\}\{6.0221\}\backslash\text{timestento}\{23\}\}$ %
1183 $\{\backslash\text{reciprocal}\backslash\text{mol}\}$ %
1184 $[\backslash\text{reciprocal}\backslash\text{mol}]$ %
1185 $[\backslash\text{reciprocal}\backslash\text{mol}]$
1186 $\backslash\text{newphysicsconstant}\{\text{universalgrav}\}$ %
1187 $\{\backslash\text{ensuremath}\{G\}\}$ %
1188 $\{\backslash\text{mi}\@p\{6.7\}\{6.6738\}\backslash\text{timestento}\{-11\}\}$ %
1189 $\{\backslash\text{m}\backslash\text{cubed}\backslash\text{usk}\backslash\text{reciprocal}\backslash\text{kg}\backslash\text{usk}\backslash\text{s}\backslash\text{reciprocal}\backslash\text{squared}\}$ %
1190 $[\backslash\text{J}\backslash\text{usk}\backslash\text{m}\backslash\text{per}\backslash\text{kg}\backslash\text{squared}]$ %
1191 $[\backslash\text{N}\backslash\text{usk}\backslash\text{m}\backslash\text{squared}\backslash\text{per}\backslash\text{kg}\backslash\text{squared}]$
1192 $\backslash\text{newphysicsconstant}\{\text{surfacegravfield}\}$ %
1193 $\{\backslash\text{ensuremath}\{g\}\}$ %
1194 $\{\backslash\text{mi}\@p\{9.8\}\{9.80\}\}$ %
1195 $\{\backslash\text{m}\backslash\text{usk}\backslash\text{s}\backslash\text{reciprocal}\backslash\text{squared}\}$ %
1196 $[\backslash\text{N}\backslash\text{per}\backslash\text{kg}]$ %
1197 $[\backslash\text{N}\backslash\text{per}\backslash\text{kg}]$
1198 $\backslash\text{newphysicsconstant}\{\text{clight}\}$ %
1199 $\{\backslash\text{ensuremath}\{c\}\}$ %
1200 $\{\backslash\text{mi}\@p\{3\}\{2.9979\}\backslash\text{timestento}\{8\}\}$ %
1201 $\{\backslash\text{m}\backslash\text{usk}\backslash\text{reciprocal}\backslash\text{s}\}$ %
1202 $[\backslash\text{m}\backslash\text{per}\backslash\text{s}]$ %
1203 $[\backslash\text{m}\backslash\text{per}\backslash\text{s}]$
1204 $\backslash\text{newphysicsconstant}\{\text{clightinfeet}\}$ %
1205 $\{\backslash\text{ensuremath}\{c\}\}$ %
1206 $\{\backslash\text{mi}\@p\{1\}\{0.9836\}\}$ %
1207 $\{\backslash\text{text}\{\text{ft}\}\backslash\text{usk}\backslash\text{reciprocal}\{\backslash\text{text}\{n\}\backslash\text{s}\}\}$ %
1208 $[\backslash\text{text}\{\text{ft}\}\backslash\text{per}\backslash\text{text}\{n\}\backslash\text{s}]$ %
1209 $[\backslash\text{text}\{\text{ft}\}\backslash\text{per}\backslash\text{mathrm}\{n\}\backslash\text{s}]$
1210 $\backslash\text{newphysicsconstant}\{\text{Ratom}\}$ %
1211 $\{\backslash\text{ensuremath}\{r_{\backslash\text{text}\{\text{atom}\}}\}\}$ %
1212 $\{\backslash\text{tento}\{-10\}\}$ %
1213 $\{\backslash\text{m}\}$ %
1214 $[\backslash\text{m}]$ %

```

1215 [\m]
1216 \newphysicsconstant{Mproton}%
1217 {\ensuremath{m_p}}%
1218 {\mi@p{1.7}{1.6726}\timestento{-27}}%
1219 {\kg}%
1220 [\kg]%
1221 [\kg]
1222 \newphysicsconstant{Mneutron}%
1223 {\ensuremath{m_n}}%
1224 {\mi@p{1.7}{1.6749}\timestento{-27}}%
1225 {\kg}%
1226 [\kg]%
1227 [\kg]
1228 \newphysicsconstant{Mhydrogen}%
1229 {\ensuremath{m_H}}%
1230 {\mi@p{1.7}{1.6737}\timestento{-27}}%
1231 {\kg}%
1232 [\kg]%
1233 [\kg]
1234 \newphysicsconstant{Melectron}%
1235 {\ensuremath{m_e}}%
1236 {\mi@p{9.1}{9.1094}\timestento{-31}}%
1237 {\kg}%
1238 [\kg]%
1239 [\kg]
1240 \newphysicsconstant{echarge}%
1241 {\ensuremath{e}}%
1242 {\mi@p{1.6}{1.6022}\timestento{-19}}%
1243 {\A\usk\s}%
1244 [\C]%
1245 [\C]
1246 \newphysicsconstant{Qelectron}%
1247 {\ensuremath{Q_e}}%
1248 {-\echargevalue}%
1249 {\A\usk\s}%
1250 [\C]%
1251 [\C]
1252 \newphysicsconstant{qelectron}%
1253 {\ensuremath{q_e}}%
1254 {-\echargevalue}%
1255 {\A\usk\s}%
1256 [\C]%
1257 [\C]
1258 \newphysicsconstant{Qproton}%
1259 {\ensuremath{Q_p}}%
1260 {+\echargevalue}%
1261 {\A\usk\s}%
1262 [\C]%
1263 [\C]
1264 \newphysicsconstant{qproton}%

```


1265 $\{\backslashensuremath{q_p}\}$ %
1266 $\{+\backslashechargevalue\}$ %
1267 $\{\backslashA\usk\backslashs\}$ %
1268 $[\backslashC]$ %
1269 $[\backslashC]$
1270 $\backslashnewphysicsconstant\{M\text{Earth}\}$ %
1271 $\{\backslashensuremath{M_{\text{Earth}}}\}$ %
1272 $\{\backslashmi@p{6.0}\{5.9736\}\backslashtimestento{24}\}$ %
1273 $\{\backslashkg\}$ %
1274 $[\backslashkg]$ %
1275 $[\backslashkg]$
1276 $\backslashnewphysicsconstant\{M\text{Moon}\}$ %
1277 $\{\backslashensuremath{M_{\text{Moon}}}\}$ %
1278 $\{\backslashmi@p{7.3}\{7.3459\}\backslashtimestento{22}\}$ %
1279 $\{\backslashkg\}$ %
1280 $[\backslashkg]$ %
1281 $[\backslashkg]$
1282 $\backslashnewphysicsconstant\{M\text{Sun}\}$ %
1283 $\{\backslashensuremath{M_{\text{Sun}}}\}$ %
1284 $\{\backslashmi@p{2.0}\{1.9891\}\backslashtimestento{30}\}$ %
1285 $\{\backslashkg\}$ %
1286 $[\backslashkg]$ %
1287 $[\backslashkg]$
1288 $\backslashnewphysicsconstant\{R\text{Earth}\}$ %
1289 $\{\backslashensuremath{R_{\text{Earth}}}\}$ %
1290 $\{\backslashmi@p{6.4}\{6.3675\}\backslashtimestento{6}\}$ %
1291 $\{\backslashm\}$ %
1292 $[\backslashm]$ %
1293 $[\backslashm]$
1294 $\backslashnewphysicsconstant\{R\text{Moon}\}$ %
1295 $\{\backslashensuremath{R_{\text{Moon}}}\}$ %
1296 $\{\backslashmi@p{1.7}\{1.7375\}\backslashtimestento{6}\}$ %
1297 $\{\backslashm\}$ %
1298 $[\backslashm]$ %
1299 $[\backslashm]$
1300 $\backslashnewphysicsconstant\{R\text{Sun}\}$ %
1301 $\{\backslashensuremath{R_{\text{Sun}}}\}$ %
1302 $\{\backslashmi@p{7.0}\{6.9634\}\backslashtimestento{8}\}$ %
1303 $\{\backslashm\}$ %
1304 $[\backslashm]$ %
1305 $[\backslashm]$
1306 $\backslashnewphysicsconstant\{ES\text{dist}\}$ %
1307 $\{\backslashmagvectsub{r}\{ES\}\}$ %
1308 $\{\backslashmi@p{1.5}\{1.4960\}\backslashtimestento{11}\}$ %
1309 $\{\backslashm\}$ %
1310 $[\backslashm]$ %
1311 $[\backslashm]$
1312 $\backslashnewphysicsconstant\{SE\text{dist}\}$ %
1313 $\{\backslashmagvectsub{r}\{SE\}\}$ %
1314 $\{\backslashmi@p{1.5}\{1.4960\}\backslashtimestento{11}\}$ %

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1315 {\m}%
1316 [\m]%
1317 [\m]
1318 \newphysicsconstant{EMdist}%
1319 {\magvectsub{r}{EM}}%
1320 {\mi@p{3.8}{3.8440}\timestento{8}}%
1321 {\m}%
1322 [\m]%
1323 [\m]
1324 \newphysicsconstant{MEDist}%
1325 {\magvectsub{r}{ME}}%
1326 {\mi@p{3.8}{3.8440}\timestento{8}}%
1327 {\m}%
1328 [\m]%
1329 [\m]
1330 \newphysicsconstant{LSun}%
1331 {\ensuremath{L_{\text{Sun}}}}%
1332 {\mi@p{3.8}{3.8460}\timestento{26}}%
1333 {\m\squared\usk\kg\usk\s\reciprocalcubed}%
1334 [\W]
1335 [\J\per\s]
1336 \newphysicsconstant{TSun}%
1337 {\ensuremath{T_{\text{Sun}}}}%
1338 {\mi@p{5800}{5778}}%
1339 {\K}%
1340 [\K]%
1341 [\K]
1342 \newphysicsconstant{MagSun}%
1343 {\ensuremath{M_{\text{Sun}}}}%
1344 {+4.83}%
1345 {}%
1346 []%
1347 []
1348 \newphysicsconstant{magSun}%
1349 {\ensuremath{m_{\text{Sun}}}}%
1350 {-26.74}%
1351 {}%
1352 []%
1353 []
1354 \newcommand*{\coulombconstant}{\oofpez}
1355 \newcommand*{\altcoulombconstant}{\oofpezcs}
1356 \newcommand*{\biotsavartconstant}{\mzofp}
1357 \newcommand*{\boltzmannconstant}{\boltzmann}
1358 \newcommand*{\stefanboltzmannconstant}{\stefanboltzmann}
1359 \newcommand*{\planckconstant}{\planck}
1360 \newcommand*{\reducedplanckconstant}{\planckbar}
1361 \newcommand*{\planckconstanttimesc}{\planckc}
1362 \newcommand*{\rydbergconstant}{\rydberg}
1363 \newcommand*{\finestructureconstant}{\finestructure}
1364 \newcommand*{\avogadroconstant}{\avogadro}

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1365 \newcommand*{\universalgravitationalconstant}{\universalgrav}
1366 \newcommand*{\earthssurfacegravitationalfield}{\surfacegravfield}
1367 \newcommand*{\photonconstant}{\cflight}
1368 \newcommand*{\elementarycharge}{\echarge}
1369 \newcommand*{\EarthSundistance}{\ESdist}
1370 \newcommand*{\SunEarthdistance}{\SEdist}
1371 \newcommand*{\EarthMoondistance}{\ESdist}
1372 \newcommand*{\MoonEarthdistance}{\SEdist}
1373 \newcommand*{\Lstar}[1][\(\star\)]{\ensuremath{L_{\text{\text{#1}}}}\xspace}
1374 \newcommand*{\Lsolar}{\ensuremath{\Lstar[\(\odot\)]}\xspace}
1375 \newcommand*{\Tstar}[1][\(\star\)]{\ensuremath{T_{\text{\text{#1}}}}\xspace}
1376 \newcommand*{\Tsolar}{\ensuremath{\Tstar[\(\odot\)]}\xspace}
1377 \newcommand*{\Rstar}[1][\(\star\)]{\ensuremath{R_{\text{\text{#1}}}}\xspace}
1378 \newcommand*{\Rsolar}{\ensuremath{\Rstar[\(\odot\)]}\xspace}
1379 \newcommand*{\Mstar}[1][\(\star\)]{\ensuremath{M_{\text{\text{#1}}}}\xspace}
1380 \newcommand*{\Msolar}{\ensuremath{\Mstar[\(\odot\)]}\xspace}
1381 \newcommand*{\Fstar}[1][\(\star\)]{\ensuremath{F_{\text{\text{#1}}}}\xspace}
1382 \newcommand*{\fstar}[1][\(\star\)]{\ensuremath{f_{\text{\text{#1}}}}\xspace}
1383 \newcommand*{\Fsolar}{\ensuremath{\Fstar[\(\odot\)]}\xspace}
1384 \newcommand*{\fsolar}{\ensuremath{\fstar[\(\odot\)]}\xspace}
1385 \newcommand*{\Magstar}[1][\(\star\)]{\ensuremath{M_{\text{\text{#1}}}}\xspace}
1386 \newcommand*{\magstar}[1][\(\star\)]{\ensuremath{m_{\text{\text{#1}}}}\xspace}
1387 \newcommand*{\Magsolar}{\ensuremath{\Magstar[\(\odot\)]}\xspace}
1388 \newcommand*{\magsolar}{\ensuremath{\magstar[\(\odot\)]}\xspace}
1389 \newcommand*{\Dstar}[1][\(\star\)]{\ensuremath{D_{\text{\text{#1}}}}\xspace}
1390 \newcommand*{\dstar}[1][\(\star\)]{\ensuremath{d_{\text{\text{#1}}}}\xspace}
1391 \newcommand*{\Dsolar}{\ensuremath{\Dstar[\(\odot\)]}\xspace}
1392 \newcommand*{\dsolar}{\ensuremath{\dstar[\(\odot\)]}\xspace}
1393 \newcommand*{\onehalf}{\ensuremath{\frac{1}{2}}\xspace}
1394 \newcommand*{\onethird}{\ensuremath{\frac{1}{3}}\xspace}
1395 \newcommand*{\onefourth}{\ensuremath{\frac{1}{4}}\xspace}
1396 \newcommand*{\onefifth}{\ensuremath{\frac{1}{5}}\xspace}
1397 \newcommand*{\onesixth}{\ensuremath{\frac{1}{6}}\xspace}
1398 \newcommand*{\oneseventh}{\ensuremath{\frac{1}{7}}\xspace}
1399 \newcommand*{\oneeighth}{\ensuremath{\frac{1}{8}}\xspace}
1400 \newcommand*{\oneninth}{\ensuremath{\frac{1}{9}}\xspace}
1401 \newcommand*{\onetenth}{\ensuremath{\frac{1}{10}}\xspace}
1402 \newcommand*{\twooneths}{\ensuremath{\frac{2}{1}}\xspace}
1403 \newcommand*{\twohalves}{\ensuremath{\frac{2}{2}}\xspace}
1404 \newcommand*{\twothirds}{\ensuremath{\frac{2}{3}}\xspace}
1405 \newcommand*{\twofourths}{\ensuremath{\frac{2}{4}}\xspace}
1406 \newcommand*{\twofifths}{\ensuremath{\frac{2}{5}}\xspace}
1407 \newcommand*{\twosixths}{\ensuremath{\frac{2}{6}}\xspace}
1408 \newcommand*{\twosevenths}{\ensuremath{\frac{2}{7}}\xspace}
1409 \newcommand*{\twoeighths}{\ensuremath{\frac{2}{8}}\xspace}
1410 \newcommand*{\twoninths}{\ensuremath{\frac{2}{9}}\xspace}
1411 \newcommand*{\twotenths}{\ensuremath{\frac{2}{10}}\xspace}
1412 \newcommand*{\threeoneths}{\ensuremath{\frac{3}{1}}\xspace}
1413 \newcommand*{\threehalves}{\ensuremath{\frac{3}{2}}\xspace}
1414 \newcommand*{\three thirds}{\ensuremath{\frac{3}{3}}\xspace}

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1415 \newcommand*{\threefourths}{\ensuremath{\frac{3}{4}}\xspace}
1416 \newcommand*{\threefifths}{\ensuremath{\frac{3}{5}}\xspace}
1417 \newcommand*{\threesixths}{\ensuremath{\frac{3}{6}}\xspace}
1418 \newcommand*{\threesevenths}{\ensuremath{\frac{3}{7}}\xspace}
1419 \newcommand*{\threeeighths}{\ensuremath{\frac{3}{8}}\xspace}
1420 \newcommand*{\threeninths}{\ensuremath{\frac{3}{9}}\xspace}
1421 \newcommand*{\threetenths}{\ensuremath{\frac{3}{10}}\xspace}
1422 \newcommand*{\fouroneths}{\ensuremath{\frac{4}{1}}\xspace}
1423 \newcommand*{\fourhalves}{\ensuremath{\frac{4}{2}}\xspace}
1424 \newcommand*{\fourthirds}{\ensuremath{\frac{4}{3}}\xspace}
1425 \newcommand*{\fourfourths}{\ensuremath{\frac{4}{4}}\xspace}
1426 \newcommand*{\fourfifths}{\ensuremath{\frac{4}{5}}\xspace}
1427 \newcommand*{\foursixths}{\ensuremath{\frac{4}{6}}\xspace}
1428 \newcommand*{\foursevenths}{\ensuremath{\frac{4}{7}}\xspace}
1429 \newcommand*{\foureighths}{\ensuremath{\frac{4}{8}}\xspace}
1430 \newcommand*{\fourninths}{\ensuremath{\frac{4}{9}}\xspace}
1431 \newcommand*{\fourtenths}{\ensuremath{\frac{4}{10}}\xspace}
1432 \newcommand*{\sumoverall}[1]{\ensuremath{\displaystyle
1433 \sum_{\substack{\text{\tiny{all}}\text{\tiny{\#1}}}}}
1434 \newcommand*{\dx}[1]{\ensuremath{\mathrm{d}\#1}}
1435 \newcommand*{\evalfromto}[3]{\ensuremath{\%
1436 \Bigg.\#1\Bigg\rvert_{\#2}^{\#3}}}
1437 \newcommand*{\evalat}[2]{\ensuremath{\Bigg.\#1\Bigg\rvert_{\#2}}}
1438 \newcommand*{\evaluatedat}[1]{\ensuremath{\Bigg.\Bigg\rvert_{\#1}}}
1439 \newcommandx{\integral}[4][1,2,usedefault]{\ensuremath{\%
1440 \int_{\ifthenelse{\equal{\#1}{}}{\#4=\#1}}{\ifthenelse{\%
1441 \equal{\#2}{}}{\#4=\#2}}{\#3}\mathrm{d}\#4}}
1442 \newcommand*{\opensurfaceintegral}[2]{\ensuremath{\%
1443 \iint\limits_{\#1}\mathrm{vec}\mathrm{dot}\mathrm{vec}\#2\{\mathrm{dir}\mathrm{ect}\#n\}\mathrm{d}\mathrm{x}\{A\}}}
1444 \newcommand*{\closedsurfaceintegral}[2]{\ensuremath{\%
1445 \varoiint\limits_{\#1}\mathrm{vec}\mathrm{dot}\mathrm{vec}\#2\{\mathrm{dir}\mathrm{ect}\#n\}\mathrm{d}\mathrm{x}\{A\}}}
1446 \newcommand*{\openlineintegral}[2]{\ensuremath{\%
1447 \int\limits_{\#1}\mathrm{vec}\mathrm{dot}\mathrm{vec}\#2\{\mathrm{dir}\mathrm{ect}\#t\}\mathrm{d}\mathrm{x}\{\ell\}}}
1448 \newcommand*{\closedlineintegral}[2]{\ensuremath{\%
1449 \oint\limits_{\#1}\mathrm{vec}\mathrm{dot}\mathrm{vec}\#2\{\mathrm{dir}\mathrm{ect}\#t\}\mathrm{d}\mathrm{x}\{\ell\}}}
1450 \newcommand*{\volumeintegral}[2]{\ensuremath{\%
1451 \iiint\limits_{\#1}\#2\mathrm{d}\mathrm{x}\{V\}}}
1452 \newcommandx{\dbydt}[1][1]{\ensuremath{\%
1453 \frac{\mathrm{d}\#1}{\mathrm{d}t}}}
1454 \newcommandx{\DbyDt}[1][1]{\ensuremath{\%
1455 \frac{\Delta\#1}{\Delta t}}}
1456 \newcommandx{\ddbydt}[1][1]{\ensuremath{\%
1457 \frac{\mathrm{d}^2\#1}{\mathrm{d}t^2}}}
1458 \newcommandx{\DDbyDt}[1][1]{\ensuremath{\%
1459 \frac{\Delta^2\#1}{\Delta t^2}}}
1460 \newcommandx{\pbypt}[1][1]{\ensuremath{\%
1461 \frac{\partial\#1}{\partial t}}}
1462 \newcommandx{\ppbypt}[1][1]{\ensuremath{\%
1463 \frac{\partial^2\#1}{\partial t^2}}}
1464 \newcommand*{\dbyd}[2]{\ensuremath{\frac{\%

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1465 \mathrm{d}{#1}{\mathrm{d}{#2}}
1466 \newcommand*\DbyD}[2]{\ensuremath{\frac{%
1467 \Delta{#1}}{\Delta{#2}}}}
1468 \newcommand*\ddbyd}[2]{\ensuremath{%
1469 \frac{\mathrm{d}^2{#1}}{\mathrm{d}^2{#2}}}
1470 \newcommand*\DDbyD}[2]{\ensuremath{%
1471 \frac{\Delta^2{#1}}{\Delta^2{#2}}}
1472 \newcommand*\pbyp}[2]{\ensuremath{%
1473 \frac{\partial{#1}}{\partial{#2}}}
1474 \newcommand*\ppbyp}[2]{\ensuremath{%
1475 \frac{\partial^2{#1}}{\partial^2{#2}}}
1476 \newcommand*\seriesofx{\ensuremath{%
1477 f(x) \approx f(a) + \frac{f'(a)}{1!}(x-a) + \frac{f''(a)}{2!}
1478 (x-a)^2 + \frac{f'''(a)}{3!}(x-a)^3 + \ldots\} \xspace}
1479 \newcommand*\seriesexp{x}{\ensuremath{%
1480 e^x \approx 1 + x + \frac{x^2}{2!} + \frac{x^3}{3!} + \ldots\} \xspace}
1481 \newcommand*\seriesinx{\ensuremath{%
1482 \sin x \approx x - \frac{x^3}{3!} + \frac{x^5}{5!} - \ldots\} \xspace}
1483 \newcommand*\seriescosx{\ensuremath{%
1484 \cos x \approx 1 - \frac{x^2}{2!} + \frac{x^4}{4!} - \ldots\} \xspace}
1485 \newcommand*\seriesatnx{\ensuremath{%
1486 \tan x \approx x + \frac{x^3}{3} + \frac{2x^5}{15} + \ldots\} \xspace}
1487 \newcommand*\seriesatox{\ensuremath{%
1488 a^x \approx 1 + x \ln a + \frac{(x \ln a)^2}{2!} + \frac{(x \ln a)^3}{3!} + %
1489 \ldots\} \xspace}
1490 \newcommand*\serieslnoneplusx{\ensuremath{%
1491 \ln(1 \pm x) \approx \pm x - \frac{x^2}{2} \pm \frac{x^3}{3} - %
1492 \frac{x^4}{4} \pm \ldots\} \xspace}
1493 \newcommand*\binomialseries{\ensuremath{%
1494 (1 + x)^n \approx 1 + nx + \frac{n(n-1)}{2!}x^2 + \ldots\} \xspace}
1495 \newcommand*\gradient{\ensuremath{\boldsymbol{\nabla}}}
1496 \newcommand*\divergence{\ensuremath{\boldsymbol{\nabla}\bullet}}
1497 \newcommand*\curl{\ensuremath{\boldsymbol{\nabla}\times}}
1498 \newcommand{\taigrad}{\ensuremath{\nabla}}%
1499 \newcommand{\taisvec}{\ensuremath{\nabla}}%
1500 \stackinset{c}{0.07ex}{c}{0.1ex}{\tiny$-$}{\nabla$}
1501 }%
1502 \newcommand{\taidivg}{\ensuremath{\nabla}}%
1503 \stackinset{c}{0.07ex}{c}{0.1ex}{\tiny$\cdot$}{\nabla$}
1504 }%
1505 \newcommand{\taicurl}{\ensuremath{\nabla}}%
1506 \stackinset{c}{0.04ex}{c}{0.32ex}{\tiny$\times$}{\nabla$}
1507 }%
1508 \newcommand*\laplacian{\ensuremath{\boldsymbol{\nabla}^2}}
1509 \newcommand*\dalembertian{\ensuremath{\boldsymbol{\Box}}}
1510 \newcommand*\diracdelta[1]{\ensuremath{\delta}(#1)}
1511 \newcommand*\orderof[1]{\ensuremath{\mathcal{O}}(#1)}
1512 \DeclareMathOperator{\asin}{\sin^{-1}}
1513 \DeclareMathOperator{\acos}{\cos^{-1}}
1514 \DeclareMathOperator{\atan}{\tan^{-1}}

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1515 \DeclareMathOperator{\asec}{\sec^{-1}}
1516 \DeclareMathOperator{\acsc}{\csc^{-1}}
1517 \DeclareMathOperator{\acot}{\cot^{-1}}
1518 \DeclareMathOperator{\sech}{sech}
1519 \DeclareMathOperator{\csch}{csch}
1520 \DeclareMathOperator{\asinh}{\sinh^{-1}}
1521 \DeclareMathOperator{\acosh}{\cosh^{-1}}
1522 \DeclareMathOperator{\atanh}{\tanh^{-1}}
1523 \DeclareMathOperator{\asech}{\sech^{-1}}
1524 \DeclareMathOperator{\acsch}{\csch^{-1}}
1525 \DeclareMathOperator{\acoth}{\coth^{-1}}
1526 \DeclareMathOperator{\sgn}{sgn}
1527 \DeclareMathOperator{\dex}{dex}
1528 \newcommand*{\logb}[1][\relax]{\ensuremath{\log_{#1}}}
1529 \ifthenelse{\boolean{@optboldvectors}}
1530   {\newcommand*{\cB}{\ensuremath{\boldsymbol{c\mskip -3.00mu B}}}}
1531   {\ifthenelse{\boolean{@optromanvectors}}
1532     {\newcommand*{\cB}{\ensuremath{\textsf{c}\mskip -3.00mu\mathrm{B}}}}
1533     {\newcommand*{\cB}{\ensuremath{c\mskip -3.00mu B}}}}
1534 \newcommand*{\newpi}{\ensuremath{\pi\mskip -7.8mu\pi}}
1535 \newcommand*{\scripty}[1]{\ensuremath{\mathcalligra{#1}}}
1536 \newcommand*{\Lagr}{\ensuremath{\mathcal{L}}}
1537 \newcommandx{\flux}[1][1]{\ensuremath{\ssub{\Phi}{#1}}}
1538 \newcommand*{\absof}[1]{\ensuremath{%
1539   \left\lvert\ifblank{#1}{\:\cdot\:}{#1}\right\rvert}}
1540 \newcommand*{\inparens}[1]{\ensuremath{%
1541   \left(\ifblank{#1}{\:\cdot\:}{#1}\right)}
1542 \newcommand*{\magof}[1]{\ensuremath{%
1543   \left\lVert\ifblank{#1}{\:\cdot\:}{#1}\right\rVert}}
1544 \newcommand*{\dimsof}[1]{\ensuremath{%
1545   \left[\ifblank{#1}{\:\cdot\:}{#1}\right]}
1546 \newcommand*{\unitsof}[1]{\ensuremath{%
1547   \left[\ifblank{#1}{\:\cdot\:}{#1}\right]_u}}
1548 \newcommand*{\changein}[1]{\ensuremath{\delta{#1}}}
1549 \newcommand*{\Changein}[1]{\ensuremath{\Delta{#1}}}
1550 \newcommandx{\scin}[3][1,3=\!\!,usedefault]{\ensuremath{%
1551   \ifthenelse{\equal{#1}{}}
1552     {\unit{10^{#2}}{#3}}
1553     {\unit{#1}\times 10^{#2}{#3}}}
1554 \newcommandx{\timestento}[2][2=\!\!,usedefault]{\ensuremath{%
1555   \ifthenelse{\equal{#2}{}}
1556     {\unit{\;\times\;10^{#1}}}
1557     {\unit{\;\times\;10^{#1}}{#2}}}
1558 \newcommand*{\xtento}{\timestento}
1559 \newcommandx{\tento}[2][2=\!\!,usedefault]{\ensuremath{%
1560   \ifthenelse{\equal{#2}{}}
1561     {\unit{10^{#1}}}
1562     {\unit{10^{#1}}{#2}}}
1563 \newcommand*{\ee}[2]{\texttt{#1}e{#2}}
1564 \newcommand*{\EE}[2]{\texttt{#1}E{#2}}

```

```

1565 \newcommand*\dms}[3]{\ensuremath{%
1566 \indegrees{#1}\inarcminutes{#2}\inarcseconds{#3}}
1567 \newcommand*\hms}[3]{\ensuremath{%
1568 {#1}^{\hour}{#2}^{\mathrm{m}}{#3}^{\s}}
1569 \newcommand*\clockreading{\hms}
1570 \newcommand*\latitude}[1]{\unit{#1}{\degree}}
1571 \newcommand*\latitudeN}[1]{\unit{#1}{\degree\; \mathrm{N}}}
1572 \newcommand*\latitudeS}[1]{\unit{#1}{\degree\; \mathrm{S}}}
1573 \newcommand*\longitude}[1]{\unit{#1}{\degree}}
1574 \newcommand*\longitudeE}[1]{\unit{#1}{\degree\; \mathrm{E}}}
1575 \newcommand*\longitudeW}[1]{\unit{#1}{\degree\; \mathrm{W}}}
1576 \newcommand*\ssub}[2]{\ensuremath{#1_{\text{#2}}}}
1577 \newcommand*\ssup}[2]{\ensuremath{#1^{\text{#2}}}}
1578 \newcommand*\ssud}[3]{\ensuremath{#1^{\text{#2}}_{\text{#3}}}}
1579 \newcommand*\msub}[2]{\ensuremath{#1_{#2}}}
1580 \newcommand*\msup}[2]{\ensuremath{#1^{#2}}}
1581 \newcommand*\msud}[3]{\ensuremath{#1^{#2}_{#3}}}
1582 \newcommand*\levicivita}[1]{\ensuremath{%
1583 \varepsilon_{\scriptscriptstyle#1}}}
1584 \newcommand*\kronecker}[1]{\ensuremath{%
1585 \delta_{\scriptscriptstyle#1}}}
1586 \newcommand*\xaxis{\ensuremath{x\text{-axis}}\xspace}
1587 \newcommand*\yaxis{\ensuremath{y\text{-axis}}\xspace}
1588 \newcommand*\zaxis{\ensuremath{z\text{-axis}}\xspace}
1589 \newcommand*\naxis}[1]{\ensuremath{#1\text{-axis}}\xspace}
1590 \newcommand*\axis{\ensuremath{\text{-axis}}\xspace}
1591 \newcommand*\xyplane{\ensuremath{xy\text{-plane}}\xspace}
1592 \newcommand*\yzplane{\ensuremath{yz\text{-plane}}\xspace}
1593 \newcommand*\zxplane{\ensuremath{zx\text{-plane}}\xspace}
1594 \newcommand*\yxplane{\ensuremath{yx\text{-plane}}\xspace}
1595 \newcommand*\zyplane{\ensuremath{zy\text{-plane}}\xspace}
1596 \newcommand*\xzplane{\ensuremath{xz\text{-plane}}\xspace}
1597 \newcommand*\plane{\ensuremath{\text{-plane}}\xspace}
1598 % Frequently used roots. Prepend |f| for fractional exponents.
1599 \newcommand*\cuberoot}[1]{\ensuremath{\sqrt[3]{#1}}}
1600 \newcommand*\fourthroot}[1]{\ensuremath{\sqrt[4]{#1}}}
1601 \newcommand*\fifthroot}[1]{\ensuremath{\sqrt[5]{#1}}}
1602 \newcommand*\fsqrt}[1]{\ensuremath{#1^{\onehalf}}}
1603 \newcommand*\fcuberoot}[1]{\ensuremath{#1^{\onethird}}}
1604 \newcommand*\ffourthroot}[1]{\ensuremath{#1^{\onefourth}}}
1605 \newcommand*\ffifthroot}[1]{\ensuremath{#1^{\onefifth}}}
1606 \newcommand*\relgamma}[1]{\ensuremath{%
1607 \frac{1}{\sqrt{1-\mathrm{inparens}\frac{#1}{c}\squared}}}}
1608 \newcommand*\frelgamma}[1]{\ensuremath{%
1609 \mathrm{inparens}\frac{1}{\sqrt{1-\mathrm{inparens}\frac{#1}{c}\squared}}^{\onehalf}}}
1610 \newcommand*\oosqrtomxs}[1]{\ensuremath{\frac{1}{\sqrt{1-#1}\squared}}}
1611 \newcommand*\oosqrtomx}[1]{\ensuremath{\frac{1}{\sqrt{1-#1}}}}
1612 \newcommand*\ooomx}[1]{\ensuremath{\frac{1}{1-#1}}}
1613 \newcommand*\oopx}[1]{\ensuremath{\frac{1}{1+#1}}}
1614 \newcommand*\isequals{\wordoperator{?}{=}\xspace}

```

```

1615 \newcommand*{\wordoperator}[2]{\ensuremath{%
1616 \mathrel{\vcenter{\offinterlineskip
1617 \halign{\hfil\tiny\upshape##\hfil\cr\noalign{\vskip-.5ex}
1618   {#1}\cr\noalign{\vskip.5ex}{#2}\cr}}}}
1619 \newcommand*{\definedas}{\wordoperator{defined}{as}\xspace}
1620 \newcommand*{\associated}{\wordoperator{associated}{with}\xspace}
1621 \newcommand*{\adjustedby}{\wordoperator{adjusted}{by}\xspace}
1622 \newcommand*{\earliertan}{\wordoperator{earlier}{than}\xspace}
1623 \newcommand*{\laterthan}{\wordoperator{later}{than}\xspace}
1624 \newcommand*{\forevery}{\wordoperator{for}{every}\xspace}
1625 \newcommand*{\pwordoperator}[2]{\ensuremath{\left(%
1626 \mathrel{\vcenter{\offinterlineskip%
1627 \halign{\hfil\tiny\upshape##\hfil\cr\noalign{\vskip-.5ex}%
1628   {#1}\cr\noalign{\vskip.5ex}{#2}\cr}}\right)}}%
1629 \newcommand*{\pdefinedas}{\pwordoperator{defined}{as}\xspace}
1630 \newcommand*{\passociated}{\pwordoperator{associated}{with}\xspace}
1631 \newcommand*{\padjustedby}{\pwordoperator{adjusted}{by}\xspace}
1632 \newcommand*{\pearliertan}{\pwordoperator{earlier}{than}\xspace}
1633 \newcommand*{\platerthan}{\pwordoperator{later}{than}\xspace}
1634 \newcommand*{\pforevery}{\pwordoperator{for}{every}\xspace}
1635 \newcommand*{\defines}{\ensuremath{\stackrel{\text{\tiny{def}}}{=}}\xspace}
1636 \newcommand*{\inframe}[1][\relax]{\ensuremath{%
1637 \xrightarrow[\text{\tiny{\mathcal #1}}]{} }\xspace}
1638 \newcommand*{\associates}{\ensuremath{%
1639 \xrightarrow{\text{\tiny{assoc}}}\xspace}
1640 \newcommand*{\becomes}{\ensuremath{%
1641 \xrightarrow{\text{\tiny{becomes}}}\xspace}
1642 \newcommand*{\rrelatedto}[1]{\ensuremath{%
1643 \xrightarrow[\text{\tiny{#1}}]{} }\xspace}
1644 \newcommand*{\lrelatedto}[1]{\ensuremath{%
1645 \xrightarrow[\text{\tiny{#1}}]{} }\xspace}
1646 \newcommand*{\brelatedto}[2]{\ensuremath{%
1647 \xrightarrow[\text{\tiny{#1}}]{\text{\tiny{#2}}}\xspace}
1648 \newcommand*{\momentumprinciple}{\ensuremath{%
1649 \vectsub{p}{sys,final}=\vectsub{p}{sys,initial}+\Fnetsys\Delta t}}
1650 \newcommand*{\LHSmomentumprinciple}{\ensuremath{\vectsub{p}{sys,final}}}
1651 \newcommand*{\RHSmomentumprinciple}{\ensuremath{%
1652 \vectsub{p}{sys,initial}+\Fnetsys\Delta t}}
1653 \newcommand*{\momentumprinciplediff}{\ensuremath{%
1654 \Dvectsub{p}{sys}=\Fnetsys\Delta t}}
1655 \newcommand*{\energyprinciple}{\ensuremath{%
1656 \ssub{E}{sys,final}=\ssub{E}{sys,initial}+W+Q}}
1657 \newcommand*{\LHSEnergyprinciple}{\ensuremath{\ssub{E}{sys,final}}}
1658 \newcommand*{\RHSenergyprinciple}{\ensuremath{\ssub{E}{sys,initial}+W+Q}}
1659 \newcommand*{\energyprinciplediff}{\ensuremath{\Delta\ssub{E}{sys}=W+Q}}
1660 \newcommand*{\angularmomentumprinciple}{\ensuremath{%
1661 \vectsub{L}{(A),sys,final}=\vectsub{L}{(A),sys,initial}+\Tsub{net}\Delta t}}
1662 \newcommand*{\LHSangularmomentumprinciple}{\ensuremath{%
1663 \vectsub{L}{(A),sys,final}}}
1664 \newcommand*{\RHSangularmomentumprinciple}{\ensuremath{%

```



```

1665 \vectsub{L}{\(\A\),sys,initial}+\Tsub{net}\Delta t}}
1666 \newcommand*{\angularmomentumprinciplediff}{\ensuremath{%
1667 \Dvectsub{L}{\(\A\),sys}=\Tsub{net}\Delta t}}
1668 \newcommand*{\gravitationalinteraction}{\ensuremath{%
1669 \universalgravmathsymbol\frac{\msub{M}{1}\msub{M}{2}}{%
1670 \magvectsub{r}{12}\squared}(-\dirvectsub{r}{12})}}
1671 \newcommand*{\electricinteraction}{\ensuremath{%
1672 \oofpezmathsymbol\frac{\msub{Q}{1}\msub{Q}{2}}{\magvectsub{r}{12}\squared}
1673 \dirvectsub{r}{12}}}
1674 \newcommand*{\springinteraction}{\ensuremath{\ks\magvect{s}(-\dirvect{s})}}
1675 \newcommand*{\Bfieldofparticle}{\ensuremath{%
1676 \mzofpmathsymbol\frac{Q\magvect{v}}{\magvect{r}\squared}\dirvect{v}\times
1677 \dirvect{r}}}
1678 \newcommand*{\Efieldofparticle}{\ensuremath{%
1679 \oofpezmathsymbol\frac{Q}{\magvect{r}\squared}\dirvect{r}}}
1680 \newcommandx{\Esys}[1][1]{\ifthenelse{%
1681 \equal{#1}{}}{\ssub{E}{sys}}{\ssub{E}{sys,#1}}}
1682 \newcommandx{\Us}[1][1]{\ifthenelse{%
1683 \equal{#1}{}}{\ssub{U}{\(\s\)}}{\ssub{U}{\(\s),#1}}}
1684 \newcommandx{\Ug}[1][1]{\ifthenelse{%
1685 \equal{#1}{}}{\ssub{U}{\(\g\)}}{\ssub{U}{\(\g),#1}}}
1686 \newcommandx{\Ue}[1][1]{\ifthenelse{%
1687 \equal{#1}{}}{\ssub{U}{\(\e\)}}{\ssub{U}{\(\e),#1}}}
1688 \newcommandx{\Ktrans}[1][1]{\ifthenelse{\equal{#1}{}}{\ssub{K}{trans}}
1689 {\ssub{K}{trans,#1}}}
1690 \newcommandx{\Krot}[1][1]{\ifthenelse{%
1691 \equal{#1}{}}{\ssub{K}{rot}}{\ssub{K}{rot,#1}}}
1692 \newcommandx{\Kvib}[1][1]{\ifthenelse{%
1693 \equal{#1}{}}{\ssub{K}{vib}}{\ssub{K}{vib,#1}}}
1694 \newcommandx{\Eparticle}[1][1]{\ifthenelse{\equal{#1}{}}{\ssub{E}{particle}}
1695 {\ssub{E}{particle,#1}}}
1696 \newcommandx{\Einternal}[1][1]{\ifthenelse{\equal{#1}{}}{\ssub{E}{internal}}
1697 {\ssub{E}{internal,#1}}}
1698 \newcommandx{\Erest}[1][1]{\ifthenelse{\equal{#1}{}}{\ssub{E}{rest}}{\ssub{E}
1699 {rest,#1}}}
1700 \newcommandx{\Echem}[1][1]{\ifthenelse{\equal{#1}{}}{\ssub{E}{chem}}{\ssub{E}
1701 {chem,#1}}}
1702 \newcommandx{\Etherm}[1][1]{\ifthenelse{\equal{#1}{}}{\ssub{E}{therm}}
1703 {\ssub{E}{therm,#1}}}
1704 \newcommandx{\Evib}[1][1]{\ifthenelse{%
1705 \equal{#1}{}}{\ssub{E}{vib}}{\ssub{E}{vib,#1}}}
1706 \newcommandx{\Ephoton}[1][1]{\ifthenelse{\equal{#1}{}}{\ssub{E}{photon}}
1707 {\ssub{E}{photon,#1}}}
1708 \newcommand*{\DEsys}{\Changein\Esys}
1709 \newcommand*{\DUs}{\Changein\Us}
1710 \newcommand*{\DUg}{\Changein\Ug}
1711 \newcommand*{\DUe}{\Changein\Ue}
1712 \newcommand*{\DKtrans}{\Changein\Ktrans}
1713 \newcommand*{\DKrot}{\Changein\Krot}
1714 \newcommand*{\DKvib}{\Changein\Kvib}

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1715 \newcommand*\DEparticle{\Changein\Eparticle}
1716 \newcommand*\DEinternal{\Changein\Einternal}
1717 \newcommand*\DERest{\Changein\Erest}
1718 \newcommand*\DEchem{\Changein\Echem}
1719 \newcommand*\DEtherm{\Changein\Etherm}
1720 \newcommand*\DEvib{\Changein\Evib}
1721 \newcommand*\DEphoton{\Changein\Ephoton}
1722 \newcommand*\springpotentialenergy{\onehalf\ks\magsquaredvect{s}}
1723 \newcommand*\finalspringpotentialenergy
1724  {\ssub{\left(\springpotentialenergy\right)}{\!\!final}}
1725 \newcommand*\initialspringpotentialenergy
1726  {\ssub{\left(\springpotentialenergy\right)}{\!\!initial}}
1727 \newcommand*\gravitationalpotentialenergy{\ensuremath{%
1728  -G\frac{\msub{M}{1}\msub{M}{2}}{\magvectsub{r}{12}}}}
1729 \newcommand*\finalgravitationalpotentialenergy
1730  {\ssub{\left(\gravitationalpotentialenergy\right)}{\!\!final}}
1731 \newcommand*\initialgravitationalpotentialenergy
1732  {\ssub{\left(\gravitationalpotentialenergy\right)}{\!\!initial}}
1733 \newcommand*\electricpotentialenergy{\ensuremath{%
1734  \oofpezmathsymbolfrac{\ssub{Q}{1}\ssub{Q}{2}}{\magvectsub{r}{12}}}}
1735 \newcommand*\finalelectricpotentialenergy
1736  {\ssub{\left(\electricpotentialenergy\right)}{\!\!final}}
1737 \newcommand*\initialelectricpotentialenergy
1738  {\ssub{\left(\electricpotentialenergy\right)}{\!\!initial}}
1739 \newcommand*\ks{\msub{k}{s}}
1740 \newcommand*\Fnet{\ensuremath{\vectsub{F}{net}}}
1741 \newcommand*\Fnetext{\ensuremath{\vectsub{F}{net,ext}}}
1742 \newcommand*\Fnetsys{\ensuremath{\vectsub{F}{net,sys}}}
1743 \newcommand*\Fsub[1]{\ensuremath{\vectsub{F}{#1}}}
1744 \newcommand*\Ltotal{\ensuremath{\vectsub{L}{\(\A\),total}}}
1745 \newcommand*\Lsys{\ensuremath{\vectsub{L}{\(\A\),sys}}}
1746 \newcommand*\Lsub[1]{\ensuremath{\vectsub{L}{\(\A\),#1}}}
1747 \newcommand*\Tnet{\ensuremath{\vectsub{\tau}{\(\A\),net}}}
1748 \newcommand*\Tnetext{\ensuremath{\vectsub{\tau}{\(\A\),net,ext}}}
1749 \newcommand*\Tnetsys{\ensuremath{\vectsub{\tau}{\(\A\),net,sys}}}
1750 \newcommand*\Tsub[1]{\ensuremath{\vectsub{\tau}{\(\A\),#1}}}
1751 \newcommand*\LHSmaxwelliint[1][\partial V]{\ensuremath{%
1752  \closedsurfaceintegral{#1}{\vect{E}}}}
1753 \newcommand*\RHSmaxwelliint{\ensuremath{\frac{\ssub{Q}{\(\e\),net}}{%
1754  {\vacuumpermittivitymathsymbol}}}}
1755 \newcommand*\RHSmaxwelliinta[1][V]{\ensuremath{%
1756  \frac{1}{\vacuumpermittivitymathsymbol}\volumeintegral{#1}{\msub{\rho}{e}}}}
1757 \newcommand*\RHSmaxwelliintfree{\ensuremath{0}}
1758 \newcommand*\maxwelliint[1][\partial V]{\ensuremath{%
1759  \LHSmaxwelliint{#1}=\RHSmaxwelliint}}
1760 \newcommand*\maxwelliinta[2][1={\partial V},2={V},usedefault]{\ensuremath{%
1761  \LHSmaxwelliint{#1}=\RHSmaxwelliinta{#2}}}
1762 \newcommand*\maxwelliintfree[1][\partial V]{\ensuremath{%
1763  \LHSmaxwelliint{#1}=\RHSmaxwelliintfree}}
1764 \newcommand*\LHSmaxwelliint[1][\partial V]{\ensuremath{%

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```

1765 \closedsurfaceintegral{#1}{\vect{B}}}}
1766 \newcommand*{\RHSmaxwelliint}{\ensuremath{0}}
1767 \newcommand*{\RHSmaxwelliintm}{\ensuremath{%
1768 \vacuumpermeabilitymathsymbol\ssub{Q}{\m\,net}}}
1769 \newcommand*{\RHSmaxwelliintma}[1][V]{\ensuremath{%
1770 \vacuumpermeabilitymathsymbol\volumeintegral{#1}{\msub{\rho}{m}}}}
1771 \newcommand*{\RHSmaxwelliintfree}{\ensuremath{0}}
1772 \newcommand*{\maxwelliint}[1][\partial V]{\ensuremath{%
1773 \LHSmaxwelliint[#1]=\RHSmaxwelliint}}
1774 \newcommand*{\maxwelliintm}[1][\partial V]{\ensuremath{%
1775 \LHSmaxwelliint[#1]=\RHSmaxwelliintm}}
1776 \newcommandx*{\maxwelliintma}[2][1={\partial V},2={V},usedefault]{\ensuremath{%
1777 \LHSmaxwelliint[#1]=\RHSmaxwelliintma[#2]}}
1778 \newcommand*{\maxwelliintfree}[1][\partial V]{\ensuremath{%
1779 \LHSmaxwelliint[#1]=\RHSmaxwelliintfree}}
1780 \newcommand*{\LHSmaxwelliint}[1][\partial\Omega]{\ensuremath{%
1781 \closedlineintegral{#1}{\vect{E}}}}
1782 \newcommand*{\RHSmaxwelliint}[1][\Omega]{\ensuremath{%
1783 -\dbydt\opensurfaceintegral{#1}{\vect{B}}}}
1784 \newcommand*{\RHSmaxwelliintm}[1][\Omega]{\ensuremath{%
1785 -\dbydt\opensurfaceintegral{#1}{\vect{B}}}%
1786 -\vacuumpermeabilitymathsymbol\ssub{I}{\m\,net}}}
1787 \newcommand*{\RHSmaxwelliintma}[1][\Omega]{\ensuremath{%
1788 -\dbydt\opensurfaceintegral{#1}{\vect{B}}}%
1789 -\vacuumpermeabilitymathsymbol\opensurfaceintegral{#1}{\vectsub{J}{\m}}}}
1790 \newcommand*{\RHSmaxwelliintfree}{\RHSmaxwelliint}
1791 \newcommandx*{\maxwelliint}[2][1={\partial\Omega},2={\Omega},usedefault]%
1792 {\ensuremath{\LHSmaxwelliint[#1]=\RHSmaxwelliint[#2]}}
1793 \newcommandx*{\maxwelliintm}[2][1={\partial\Omega},2={\Omega},usedefault]%
1794 {\ensuremath{\LHSmaxwelliint[#1]=\RHSmaxwelliintm[#2]}}
1795 \newcommandx*{\maxwelliintma}[2][1={\partial\Omega},2={\Omega},usedefault]%
1796 {\ensuremath{\LHSmaxwelliint[#1]=\RHSmaxwelliintma[#2]}}
1797 \newcommand*{\maxwelliintfree}{\maxwelliint}
1798 \newcommand*{\LHSmaxwellivint}[1][\partial\Omega]{\ensuremath{%
1799 \closedlineintegral{#1}{\vect{B}}}}
1800 \newcommand*{\RHSmaxwellivint}[1][\Omega]{\ensuremath{%
1801 \vacuumpermeabilitymathsymbol\vaccumpermittivitymathsymbol%
1802 \dbydt\opensurfaceintegral{#1}{\vect{E}}+%
1803 \vacuumpermeabilitymathsymbol\ssub{I}{\e\,net}}}
1804 \newcommand*{\RHSmaxwellivinta}[1][\Omega]{\ensuremath{%
1805 \vacuumpermeabilitymathsymbol\vaccumpermittivitymathsymbol%
1806 \dbydt\opensurfaceintegral{#1}{\vect{E}}+%
1807 \vacuumpermeabilitymathsymbol\opensurfaceintegral{#1}{\vectsub{J}{\e}}}}
1808 \newcommand*{\RHSmaxwellivintfree}[1][\Omega]{\ensuremath{%
1809 \vacuumpermeabilitymathsymbol\vaccumpermittivitymathsymbol%
1810 \dbydt\opensurfaceintegral{#1}{\vect{E}}}}
1811 \newcommandx*{\maxwellivint}[2][1={\partial\Omega},2={\Omega},usedefault]%
1812 {\ensuremath{\LHSmaxwellivint[#1]=\RHSmaxwellivint[#2]}}
1813 \newcommandx*{\maxwellivinta}[2][1={\partial\Omega},2={\Omega},usedefault]%
1814 {\ensuremath{\LHSmaxwellivint[#1]=\RHSmaxwellivinta[#2]}}

```

```

1815 \newcommandx*{\maxwellivintfree}[2][1={\partial\Omega},2={\Omega},usedefault]%
1816   {\ensuremath{\LHSmaxwellivint[#1]=\RHSmaxwellivintfree[#2]}}
1817 \newcommand*{\LHSmaxwelliidif}\ensuremath{\operatorname{divergence}\{\vec{E}\}}
1818 \newcommand*{\RHSmaxwelliidif}\ensuremath{\operatorname{frac}\{\msub{\rho}\{e}\}}
1819   {\vacuumpermittivitymathsymbol}}
1820 \newcommand*{\RHSmaxwelliidiffree}\ensuremath{0}
1821 \newcommand*{\maxwelliidif}\ensuremath{\LHSmaxwelliidif=\RHSmaxwelliidif}
1822 \newcommand*{\maxwelliidiffree}\ensuremath{\LHSmaxwelliidif=\RHSmaxwelliidiffree}
1823 \newcommand*{\LHSmaxwelliidif}\ensuremath{\operatorname{divergence}\{\vec{B}\}}
1824 \newcommand*{\RHSmaxwelliidif}\ensuremath{0}
1825 \newcommand*{\RHSmaxwelliidifm}\ensuremath{\operatorname{vacuumpermeabilitymathsymbol}}
1826   {\msub{\rho}\{m}\}}
1827 \newcommand*{\RHSmaxwelliidiffree}\ensuremath{0}
1828 \newcommand*{\maxwelliidif}\ensuremath{\LHSmaxwelliidif=\RHSmaxwelliidif}
1829 \newcommand*{\maxwelliidifm}\ensuremath{\LHSmaxwelliidif=\RHSmaxwelliidifm}
1830 \newcommand*{\maxwelliidiffree}\ensuremath{\LHSmaxwelliidif=\RHSmaxwelliidiffree}
1831 \newcommand*{\LHSmaxwelliidif}\ensuremath{\operatorname{curl}\{\vec{E}\}}
1832 \newcommand*{\RHSmaxwelliidif}\ensuremath{-\operatorname{pbypt}\{\vec{B}\}}
1833 \newcommand*{\RHSmaxwelliidifm}\ensuremath{-\operatorname{pbypt}\{\vec{B}\}-\%
1834   \operatorname{vacuumpermeabilitymathsymbol}\operatorname{vectsub}\{J\}\{\m\}}
1835 \newcommand*{\RHSmaxwelliidiffree}\ensuremath{\RHSmaxwelliidif}
1836 \newcommand*{\maxwelliidif}\ensuremath{\LHSmaxwelliidif=\RHSmaxwelliidif}
1837 \newcommand*{\maxwelliidifm}\ensuremath{\LHSmaxwelliidif=\RHSmaxwelliidifm}
1838 \newcommand*{\maxwelliidiffree}\ensuremath{\LHSmaxwelliidif=\RHSmaxwelliidif}
1839 \newcommand*{\LHSmaxwellivdif}\ensuremath{\operatorname{curl}\{\vec{B}\}}
1840 \newcommand*{\RHSmaxwellivdif}\ensuremath{\operatorname{vacuumpermeabilitymathsymbol}}
1841   \operatorname{vacuumpermittivitymathsymbol}\operatorname{pbypt}\{\vec{E}\}+\%
1842   \operatorname{vacuumpermeabilitymathsymbol}\operatorname{vectsub}\{J\}\{\e\}}
1843 \newcommand*{\RHSmaxwellivdiffree}\ensuremath{\operatorname{vacuumpermeabilitymathsymbol}}
1844   \operatorname{vacuumpermittivitymathsymbol}\operatorname{pbypt}\{\vec{E}\}}
1845 \newcommand*{\maxwellivdif}\ensuremath{\LHSmaxwellivdif=\RHSmaxwellivdif}
1846 \newcommand*{\maxwellivdiffree}\ensuremath{\LHSmaxwellivdif=\RHSmaxwellivdiffree}
1847 \newcommand*{\RHSlorentzforce}\ensuremath{\msub{q}\{e\}\operatorname{left}\{\vec{E}+\%
1848   \operatorname{vectcrossvect}\{\vec{v}\}\{\vec{B}\}\operatorname{right}\}}
1849 \newcommand*{\RHSlorentzforcem}\ensuremath{\operatorname{RHSlorentzforce}+\msub{q}\{m\}\operatorname{left}\{\%
1850   \operatorname{vect}\{B\}-\operatorname{vectcrossvect}\{\vec{v}\}\{\operatorname{frac}\{\vec{E}\}\{c^2}\}\operatorname{right}\}}
1851 \newcommandx{\eulerlagrange}[1][1={q_i},usedefault]\ensuremath{\%
1852   \operatorname{pbypt}\{\operatorname{mathcal}\{L\}\{#\1\}-\operatorname{dbydt}\operatorname{inparens}\{\operatorname{pbypt}\{\operatorname{mathcal}\{L\}\}\{\operatorname{dot}\{#\1\}\}\} = 0\}}
1853 \newcommandx{\Eulerlagrange}[1][1={q_i},usedefault]\ensuremath{\%
1854   \operatorname{DbyD}\{\operatorname{mathcal}\{L\}\{#\1\}-\operatorname{DbyDt}\operatorname{inparens}\{\operatorname{DbyD}\{\operatorname{mathcal}\{L\}\}\{\operatorname{dot}\{#\1\}\}\} = 0\}}
1855 \newcommand*{\vpythonline}\lstinline[style=vpython]
1856 \lstnewenvironment{vpythonblock}[1][\lstset{style=vpython,caption={#\1}}]{
1857 \newcommand*{\vpythonfile}[1][\newpage\lstinputlisting[style=vpython,caption={#\1}]}
1858 \newcommandx{\emptyanswer}[2][1=0.80,2=0.1,usedefault]
1859   {\begin{minipage}{#\1\textwidth}\hfill\vspace{#\2\textheight}\end{minipage}}
1860 \newenvironmentx{activityanswer}[5][1=white,2=black,3=black,4=0.90,%
1861   5=0.10,usedefault]{%
1862   \def\skipper{#\5}%
1863   \def\response@fbox{\fcolorbox{#\2}{#\1}}%
1864   \begin{center}%

```

```

1865 \begin{lrbox}{\@tempboxa}%
1866 \begin{minipage}[c][#5\textheight][c]{#4\textwidth}\color{#3}%
1867 \vspace{#5\textheight}}{%
1868 \vspace{\skipper\textheight}}%
1869 \end{minipage}%
1870 \end{lrbox}%
1871 \response@fbox{\usebox{\@tempboxa}}%
1872 \end{center}%
1873 }%
1874 \newenvironmentx{adjactivityanswer}[5][1=white,2=black,3=black,4=0.90,5=0.00,%
1875 usedefault]{%
1876 \def\skipper{#5}%
1877 \def\response@fbox{\fcolorbox{#2}{#1}}%
1878 \begin{center}%
1879 \begin{lrbox}{\@tempboxa}%
1880 \begin{minipage}[c]{#4\textwidth}\color{#3}%
1881 \vspace{#5\textheight}}{%
1882 \vspace{\skipper\textheight}}%
1883 \end{minipage}%
1884 \end{lrbox}%
1885 \response@fbox{\usebox{\@tempboxa}}%
1886 \end{center}%
1887 }%
1888 \newcommandx{\emptybox}[6][1=\hfill,2=white,3=black,4=black,5=0.90,%
1889 6=0.10,usedefault]{%
1890 {\begin{center}%
1891 \fcolorbox{#3}{#2}{%
1892 \begin{minipage}[c][#6\textheight][c]{#5\textwidth}\color{#4}%
1893 {#1}}%
1894 \end{minipage}}%
1895 \vspace{\baselineskip}}%
1896 \end{center}}%
1897 }%
1898 \newcommandx{\adjemptybox}[7][1=\hfill,2=white,3=black,4=black,5=0.90,6=,%
1899 7=0.0,usedefault]{%
1900 {\begin{center}%
1901 \fcolorbox{#3}{#2}{%
1902 \begin{minipage}[c]{#5\textwidth}\color{#4}%
1903 \vspace{#7\textheight}}%
1904 {#1}}%
1905 \vspace{#7\textheight}}%
1906 \end{minipage}}%
1907 \vspace{\baselineskip}}%
1908 \end{center}}%
1909 }%
1910 \newcommandx{\answerbox}[6][1=\hfill,2=white,3=black,4=black,5=0.90,%
1911 6=0.1,usedefault]{%
1912 {\ifthenelse{\equal{#1}{}}%
1913 {\begin{center}%
1914 \fcolorbox{#3}{#2}{%

```

```

1915     \emptyanswer[#5][#6]}%
1916     \vspace{\baselineskip}%
1917     \end{center}}%
1918     {\emptybox[#1][#2][#3][#4][#5][#6]}%
1919 }%
1920 \newcommandx{\adjanswerbox}[7][1=\hfill,2=white,3=black,4=black,5=0.90,%
1921 6=0.1,7=0.0,usedefault]%
1922 {\ifthenelse{\equal{#1}{}}%
1923  {\begin{center}%
1924     \fcolorbox{#3}{#2}{%
1925     \emptyanswer[#5][#6]}%
1926     \vspace{\baselineskip}%
1927     \end{center}}%
1928  {\adjemptybox[#1][#2][#3][#4][#5][#6][#7]}%
1929 }%
1930 \newcommandx{\smallanswerbox}[6][1=\hfill,2=white,3=black,4=black,5=0.90,%
1931 6=0.10,usedefault]%
1932 {\ifthenelse{\equal{#1}{}}%
1933  {\begin{center}%
1934     \fcolorbox{#3}{#2}{%
1935     \emptyanswer[#5][#6]}%
1936     \vspace{\baselineskip}%
1937     \end{center}}%
1938  {\emptybox[#1][#2][#3][#4][#5][#6]}%
1939 }%
1940 \newcommandx{\smallanswerform}[4][1=q1,2=Response,3=0.10,4=0.90,usedefault]{%
1941  \vspace{\baselineskip}%
1942  \begin{Form}
1943  \begin{center}%
1944  \TextField[value={#2},%
1945  name=#1,%
1946  width=#4\linewidth,%
1947  height=#3\textheight,%
1948  backgroundcolor=formcolor,%
1949  multiline=true,%
1950  charsize=10pt,%
1951  bordercolor=black]}%
1952  \end{center}%
1953  \end{Form}%
1954  \vspace{\baselineskip}%
1955 }%
1956 \newcommandx{\mediumanswerbox}[6][1=\hfill,2=white,3=black,4=black,5=0.90,%
1957 6=0.20,usedefault]{%
1958  \ifthenelse{\equal{#1}{}}%
1959  {\begin{center}%
1960     \fcolorbox{#3}{#2}{%
1961     \emptyanswer[#5][#6]}%
1962     \vspace{\baselineskip}%
1963     \end{center}}%
1964  {\emptybox[#1][#2][#3][#4][#5][#6]}%

```

```

1965 }%
1966 \newcommandx{\mediumanswerform}[4] [1=q1,2=Response,3=0.20,4=0.90,usedefault]{%
1967   \vspace{\baselineskip}%
1968   \begin{Form}
1969     \begin{center}%
1970       \TextField[value={#2},%
1971         name=#1,%
1972         width=#4\linewidth,%
1973         height=#3\textheight,%
1974         backgroundcolor=formcolor,%
1975         multiline=true,%
1976         charsize=10pt,%
1977         bordercolor=black]{}%
1978     \end{center}%
1979   \end{Form}%
1980   \vspace{\baselineskip}%
1981 }%
1982 \newcommandx{\largeanswerbox}[6] [1=\hfill,2=white,3=black,4=black,5=0.90,%
1983   6=0.25,usedefault]{%
1984   \ifthenelse{\equal{#1}{}}%
1985     {\begin{center}%
1986       \fcolorbox{#3}{#2}{%
1987         \emptyanswer[#5][#6]}%
1988       \vspace{\baselineskip}%
1989     \end{center}}%
1990     {\emptybox[#1][#2][#3][#4][#5][#6]}%
1991 }%
1992 \newcommandx{\largeanswerform}[4] [1=q1,2=Response,3=0.25,4=0.90,usedefault]{%
1993   \vspace{\baselineskip}%
1994   \begin{Form}
1995     \begin{center}%
1996       \TextField[value={#2},%
1997         name=#1,%
1998         width=#4\linewidth,%
1999         height=#3\textheight,%
2000         backgroundcolor=formcolor,%
2001         multiline=true,%
2002         charsize=10pt,%
2003         bordercolor=black]{}%
2004     \end{center}%
2005   \end{Form}%
2006   \vspace{\baselineskip}%
2007 }%
2008 \newcommandx{\largeranswerbox}[6] [1=\hfill,2=white,3=black,4=black,5=0.90,%
2009   6=0.33,usedefault]{%
2010   \ifthenelse{\equal{#1}{}}%
2011     {\begin{center}%
2012       \fcolorbox{#3}{#2}{%
2013         \emptyanswer[#5][#6]}%
2014     \vspace{\baselineskip}%

```

```

2015     \end{center}}}%
2016     {\emptybox[#1][#2][#3][#4][#5][#6]}%
2017 }%
2018 \newcommandx{\largeranswerform}[4][1=q1,2=Response,3=0.33,4=0.90,%
2019   usedefault]{%
2020   \vspace{\baselineskip}%
2021   \begin{Form}
2022     \begin{center}%
2023       \TextField[value={#2},%
2024         name=#1,%
2025         width=#4\linewidth,%
2026         height=#3\textheight,%
2027         backgroundcolor=formcolor,%
2028         multiline=true,%
2029         charsize=10pt,%
2030         bordercolor=black]{}%
2031     \end{center}%
2032   \end{Form}%
2033   \vspace{\baselineskip}%
2034 }%
2035 \newcommandx{\hugeanswerbox}[6][1=\hfill,2=white,3=black,4=black,5=0.90,%
2036   6=0.50,usedefault]{%
2037   \ifthenelse{\equal{#1}{}}
2038     {\begin{center}%
2039       \fcolorbox{#3}{#2}{%
2040         \emptyanswer[#5][#6]}%
2041       \vspace{\baselineskip}%
2042     \end{center}}%
2043     {\emptybox[#1][#2][#3][#4][#5][#6]}%
2044 }%
2045 \newcommandx{\hugeanswerform}[4][1=q1,2=Response,3=0.50,4=0.90,usedefault]{%
2046   \vspace{\baselineskip}%
2047   \begin{Form}
2048     \begin{center}%
2049       \TextField[value={#2},%
2050         name=#1,%
2051         width=#4\linewidth,%
2052         height=#3\textheight,%
2053         backgroundcolor=formcolor,%
2054         multiline=true,%
2055         charsize=10pt,%
2056         bordercolor=black]{}%
2057     \end{center}%
2058   \end{Form}%
2059   \vspace{\baselineskip}%
2060 }%
2061 \newcommandx{\hugeranswerbox}[6][1=\hfill,2=white,3=black,4=black,5=0.90,%
2062   6=0.75,usedefault]{%
2063   \ifthenelse{\equal{#1}{}}%
2064     {\begin{center}%

```



```

2065     \fcolorbox{#3}{#2}{%
2066         \emptyanswer[#5][#6]}%
2067     \vspace{\baselineskip}%
2068     \end{center}}%
2069     {\emptybox[#1][#2][#3][#4][#5][#6]}%
2070 }%
2071 \newcommandx{\hugeranswerform}[4][1=q1,2=Response,3=0.75,4=0.90,usedefault]{%
2072     \vspace{\baselineskip}%
2073     \begin{Form}
2074         \begin{center}%
2075             \TextField[value={#2},%
2076                 name=#1,%
2077                 width=#4\linewidth,%
2078                 height=#3\textheight,%
2079                 backgroundcolor=formcolor,%
2080                 multiline=true,%
2081                 charsize=10pt,%
2082                 bordercolor=black]{}%
2083         \end{center}%
2084     \end{Form}%
2085     \vspace{\baselineskip}%
2086 }%
2087 \newcommandx{\fullpageanswerbox}[6][1=\hfill,2=white,3=black,4=black,5=0.90,%
2088     6=1.00,usedefault]{%
2089     \ifthenelse{\equal{#1}{}}%
2090     {\begin{center}%
2091         \fcolorbox{#3}{#2}{%
2092             \emptyanswer[#5][#6]}%
2093         \vspace{\baselineskip}%
2094         \end{center}}%
2095     {\emptybox[#1][#2][#3][#4][#5][#6]}%
2096 }%
2097 \newcommandx{\fullpageanswerform}[4][1=q1,2=Response,3=1.00,4=0.90,usedefault]{%
2098     \vspace{\baselineskip}%
2099     \begin{Form}
2100         \begin{center}%
2101             \TextField[value={#2},%
2102                 name=#1,%
2103                 width=#4\linewidth,%
2104                 height=#3\textheight,%
2105                 backgroundcolor=formcolor,%
2106                 multiline=true,%
2107                 charsize=10pt,%
2108                 bordercolor=black]{}%
2109         \end{center}%
2110     \end{Form}%
2111     \vspace{\baselineskip}%
2112 }%
2113 \mdfdefinestyle{miinstructornotestyle}{%
2114     hidealllines=false,skipbelow=\baselineskip,skipabove=\baselineskip,

```

```

2115 leftmargin=40pt,rightmargin=40pt,linewidth=1,roundcorner=10,
2116 nobreak=true,
2117 frametitle={INSTRUCTOR NOTE},
2118 frametitlebackgroundcolor=cyan!60,frametitlerule=true,frametitlerulewidth=1,
2119 backgroundcolor=cyan!25,
2120 linecolor=black,fontcolor=black,shadow=true}
2121 \NewEnviron{miinstructornote}{%
2122 \begin{mdframed}[style=miinstructornotestyle]
2123 \begin{adjactivityanswer}[cyan!25][cyan!25][black]
2124 \BODY
2125 \end{adjactivityanswer}
2126 \end{mdframed}
2127 }%
2128 \mdfdefinestyle{mistudentnotestyle}{%
2129 hidealllines=false,skipbelow=\baselineskip,skipabove=\baselineskip,
2130 leftmargin=40pt,rightmargin=40pt,linewidth=1,roundcorner=10,
2131 nobreak=true,
2132 frametitle={STUDENT NOTE},
2133 frametitlebackgroundcolor=cyan!60,frametitlerule=true,frametitlerulewidth=1,
2134 backgroundcolor=cyan!25,
2135 linecolor=black,fontcolor=black,shadow=true}
2136 \NewEnviron{mistudentnote}{%
2137 \begin{mdframed}[style=mistudentnotestyle]
2138 \begin{adjactivityanswer}[cyan!25][cyan!25][black]
2139 \BODY
2140 \end{adjactivityanswer}
2141 \end{mdframed}
2142 }%
2143 \mdfdefinestyle{miderivationstyle}{%
2144 hidealllines=false,skipbelow=\baselineskip,skipabove=\baselineskip,
2145 leftmargin=0pt,rightmargin=0pt,linewidth=1,roundcorner=10,
2146 nobreak=true,
2147 frametitle={DERIVATION},
2148 frametitlebackgroundcolor=orange!60,frametitlerule=true,frametitlerulewidth=1,
2149 backgroundcolor=orange!25,
2150 linecolor=black,fontcolor=black,shadow=true}
2151 \NewEnviron{miderivation}{%
2152 \begin{mdframed}[style=miderivationstyle]
2153 \setcounter{equation}{0}
2154 \begin{align}
2155 \BODY
2156 \end{align}
2157 \end{mdframed}
2158 }%
2159 \NewEnviron{miderivation*}{%
2160 \begin{mdframed}[style=miderivationstyle]
2161 \setcounter{equation}{0}
2162 \begin{align*}
2163 \BODY
2164 \end{align*}

```

```

2165 \end{mdframed}
2166 }%
2167 \mdfdefinestyle{bwinstructornotestyle}{%
2168   hidealllines=false,skipbelow=\baselineskip,skipabove=\baselineskip,
2169   leftmargin=40pt,rightmargin=40pt,linewidth=1,roundcorner=10,
2170   nobreak=true,
2171   frametitle={INSTRUCTOR NOTE},
2172   frametitlebackgroundcolor=gray!50,frametitlerule=true,frametitlerulewidth=1,
2173   backgroundcolor=gray!20,
2174   linecolor=black,fontcolor=black,shadow=true}
2175 \NewEnviron{bwinstructornote}{%
2176   \begin{mdframed}[style=bwinstructornotestyle]
2177     \begin{adjactivityanswer}[gray!20][gray!20][black]
2178       \BODY
2179     \end{adjactivityanswer}
2180   \end{mdframed}
2181 }%
2182 \mdfdefinestyle{bwstudentnotestyle}{%
2183   hidealllines=false,skipbelow=\baselineskip,skipabove=\baselineskip,
2184   leftmargin=40pt,rightmargin=40pt,linewidth=1,roundcorner=10,
2185   nobreak=true,
2186   frametitle={STUDENT NOTE},
2187   frametitlebackgroundcolor=gray!50,frametitlerule=true,frametitlerulewidth=1,
2188   backgroundcolor=gray!20,
2189   linecolor=black,fontcolor=black,shadow=true}
2190 \NewEnviron{bwstudentnote}{%
2191   \begin{mdframed}[style=bwstudentnotestyle]
2192     \begin{adjactivityanswer}[gray!20][gray!20][black]
2193       \BODY
2194     \end{adjactivityanswer}
2195   \end{mdframed}
2196 }%
2197 \mdfdefinestyle{bwderivationstyle}{%
2198   hidealllines=false,skipbelow=\baselineskip,skipabove=\baselineskip,
2199   leftmargin=0pt,rightmargin=0pt,linewidth=1,roundcorner=10,
2200   nobreak=true,
2201   frametitle={DERIVATION},
2202   frametitlebackgroundcolor=gray!50,frametitlerule=true,frametitlerulewidth=1,
2203   backgroundcolor=gray!20,
2204   linecolor=black,fontcolor=black,shadow=true}
2205 \NewEnviron{bwderivation}{%
2206   \begin{mdframed}[style=bwderivationstyle]
2207     \setcounter{equation}{0}
2208     \begin{align}
2209       \BODY
2210     \end{align}
2211   \end{mdframed}
2212 }%
2213 \NewEnviron{bwderivation*}{%
2214   \begin{mdframed}[style=bwderivationstyle]

```

```

2215 \setcounter{equation}{0}
2216 \begin{align*}
2217 \BODY
2218 \end{align*}
2219 \end{mdframed}
2220 }%
2221 \NewEnviron{mysolution}{%
2222 \setcounter{equation}{0}
2223 \begin{align}
2224 \BODY
2225 \end{align}
2226 }%
2227 \NewEnviron{mysolution*}{%
2228 \setcounter{equation}{0}
2229 \begin{align*}
2230 \BODY
2231 \end{align*}
2232 }%
2233 \newcommand*\checkpoint{%
2234 \vspace{1cm}\begin{center}%
2235 \colorbox{yellow!80}{|----- CHECKPOINT -----|}%
2236 \end{center}}%
2237 \newcommand*\image}[2]{%
2238 \begin{figure}[h!]
2239 \begin{center}%
2240 \includegraphics[scale=1]{#1}%
2241 \caption{#2}%
2242 \label{#1}%
2243 \end{center}%
2244 \end{figure}}
2245 %changes{v2.5.0}{2015/09/13}{Changed behavior of \cs{sneakyone}.}
2246 \newcommand*\sneakyone}[1]{\ensuremath{\cancelto{1}{#1}}}
2247 % undocumented diagnostic command
2248 \newcommand*\chkquantity}[1]{%
2249 \begin{center}
2250 \begin{tabular}{C{4.5cm} C{4cm} C{4cm} C{4cm}}
2251 name & baseunit & drvdunit & tradunit \tabularnewline
2252 \cs{#1} & \csname #1onlybaseunit\endcsname & \csname #1onlydrvdunit\endcsname &
2253 \csname #1onlytradunit\endcsname
2254 \end{tabular}
2255 \end{center}
2256 }%
2257 \newcommand*\qed{\ensuremath{\text{ Q.E.D.}}}
2258 % undocumented diagnostic command
2259 \newcommand*\chkconstant}[1]{%
2260 \begin{center}
2261 \begin{tabular}{C{4cm} C{2cm} C{3cm} C{3cm} C{3cm} C{3cm}}
2262 name & symbol & value & baseunit & drvdunit & tradunit \tabularnewline
2263 \cs{#1} & \csname #1mathsymbol\endcsname & \csname #1value\endcsname &
2264 \csname #1onlybaseunit\endcsname & \csname #1onlydrvdunit\endcsname &

```

```
2265     \csname #1onlytradunit\endcsname
2266     \end{tabular}
2267 \end{center}
2268 }%
```

7 Acknowledgements

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8 Index

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