The mandi Package

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Acknowledgements

TO BE COMPLETED

Change History

v3.0.0c								
General: Initial release							(ĸ

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1 Introduction

This is the documentation for the mandi,¹ which is designed primarily for students in introductory physics courses. This document serves to document what commands mandi provides and does not necessarily fully demonstrate how students would use them. There is a separate document that serves that purpose.

1.1 Loading the Package

Load mandi as you would any package in your preamble.

\usepackage[options]{mandi}

1.2 The Package Version

\mandiversion

Typesets the current version and build date.

The version is \mandiversion\ and is a stable build.

The version is v3.0.0c dated 2021-02-20 and is a stable build.

1.3 Package Options

N 2021-01-30 N 2021-01-30

```
units=\langle type of unit\rangle
preciseconstants=\langle boolean\rangle
```

(initially unspecified, set to alternate) (initially unspecified, set to false)

Now mandi uses a key-value interface for options. The units key can be set to base, derived, or alternate. The preciseconstants key is always either true or false.

1.4 The mandisetup Command

N 2021-02-17

\mandisetup{\(options\)\}

Command to set package options on the fly after loadtime. This can be done in the preamble or inside the \begin{document}...\end{document} environment.

\mandisetup{units=base}

 $^{^{1}}$ The package name can be pronounced either with two syllables, to rhyme with candy, or with three syllables, as M and I.

2 Intelligent Commands for Physical Quantities and Constants

2.1 Physical Quantities

2.1.1 Typesetting Physical Quantities

Typesetting physical quantities and constants using semantically appropriate names, along with the correct SI units, is the core function of mandi. Take momentum as the prototypical physical quantity in an introductory physics course. Here are all the ways to access this quantity and its units in mandi.

```
\label{local_momentum} $$\operatorname{magnitude}$ $$\operatorname{commentum}_{(c_1,\ldots,c_n)}$
```

Command for momentum and its vector variant. The default units will depend on the options passed to mandi at load time. Alternate units are the default. Other units can be forced as demonstrated. The vector variants can take more than three components.

```
5 \text{ kg} \cdot \text{m/s}
\momentum{5}
\momentumvalue{5}
                                                                           5 \,\mathrm{m\cdot kg\cdot s^{-1}}
\momentumbaseunits{5}
                                                                          5\,\mathrm{N\cdot s}
\momentumderivedunits{5}
                                                                          5 \,\mathrm{kg \cdot m/s}
\momentumalternateunits{5}
\momentumonlybaseunits
                                                                          m \cdot kg \cdot s^{-1}
\momentumonlyderivedunits
\momentumonlyalternateunits
                                                                          kg·m/s
\vectormomentum{2,3,4}
                                                                           (2, 3, 4) kg·m/s
\momentum{\mivector{2,3,4}}
                                                                           \langle 2, 3, 4 \rangle \text{ kg·m/s}
```

Commands that include the name of a physical quantity typesets units, so they shouldn't be used for algebraic or symbolic values or components. One shouldn't use \vectormomentum{mv_x,mv_y,mv_z}. Use the generic \mivector{mv_x,mv_y,mv_z} instead.

2.1.2 Checking Physical Quantities

N 2021-02-16

$\checkquantity{\langle name \rangle}$

Command to check and typeset the command, base units, derived units, and alternate units of a defined physical quantity.

2.1.3 Commands For Predefined Physical Quantities

Every other defined physical quantity can be treated similarly. Just replace momentum with the quantity's name. Obviously, the variants that begin with \vector will not be defined for scalar quantities. Here are all the physical quantities, with all their units, defined in mandi. Remember that units are not present with symbolic (algebraic) quantities, so do not use the \vector variants of these commands for symbolic components. Use \mivector \(^{\top}P.31\) instead.

```
\label{eq:acceleration} $$\operatorname{celeration}(\langle magnitude \rangle) $$ \operatorname{celeration}(\langle c_1, \dots, c_n \rangle) $$
```

name	base m·s ⁻²	derived N/kg				
\amount{\(magnitude\)}						
name	base mol	derived mol	alternate mol			
lem:lem:lem:lem:lem:lem:lem:lem:lem:lem:						
${ m name}$	base rad·s ⁻²	derived rad/s²	alternate rad/s²			
$\verb \angularfrequency{ } (magni$	tude)}					
${ m name}$	base rad·s ⁻¹	derived rad/s	alternate rad/s			
lem:lem:lem:lem:lem:lem:lem:lem:lem:lem:						
name \angularimpulse	$\begin{array}{c} {\rm base} \\ {\rm m^2 \cdot kg \cdot s^{-1}} \end{array}$	derived kg·m²/s	$\begin{array}{c} {\rm alternate} \\ {\rm kg\cdot m^2/s} \end{array}$			
lem:lem:lem:lem:lem:lem:lem:lem:lem:lem:						
name	$\begin{array}{c} {\rm base} \\ {\rm m^2 \cdot kg \cdot s^{-1}} \end{array}$	derived kg·m²/s	$\begin{array}{c} \text{alternate} \\ \text{kg} \cdot \text{m}^2/\text{s} \end{array}$			
(magnite) \vectorangularvelocity{(
name	base rad∙s ⁻¹	derived rad/s	alternate rad/s			
$\area{\langle magnitude \rangle}$						
name \area	base m ²					
(magn	$aitude$ }}					
${\rm name} \\ {\tt \ \ \ \ \ \ }$	base m ⁻² ·s·A	derived C/m ²	alternate C/m ²			

\(magni	itude)}		
name \areamassdensity	base m ⁻² ·kg	derived kg/m²	alternate kg/m ²
(magnitude))}		
name \capacitance	$\begin{array}{c} base \\ m^{-2} \cdot kg^{-1} \cdot s^4 \cdot A^2 \end{array}$	derived F	alternate C/V
\charge{\langle magnitude \rangle}			
name \charge	base A·s	derived C	$\begin{array}{c} \text{alternate} \\ \text{C} \end{array}$
$\verb \cmagneticfield{ (magnit) } \\ \verb \cmagneticfield{ (magnit) } \\$			
name \cmagneticfield	$\begin{array}{c} base \\ m \cdot kg \cdot s^{-3} \cdot A^{-1} \end{array}$	derived V/m	alternate N/C
\((magnitude)\)	}		
name \conductance	$\begin{array}{c} base \\ m^{-2} {\cdot} kg^{-1} {\cdot} s^3 {\cdot} A^2 \end{array}$	derived S	alternate A/V
$\verb \conductivity \{ (magnitud) \} \} \} \} \} \} \} \} \} \} \} \} $	e)}		
name \conductivity	$\begin{array}{c} base \\ m^{-3}{\cdot}kg^{-1}{\cdot}s^3{\cdot}A^2 \end{array}$	derived S/m	$\begin{array}{c} {\rm alternate} \\ {\rm (A/m^2)/(V/m)} \end{array}$
(n	$nagnitude \}$		
name \conventionalcurrent	base A	derived C/s	alternate A
\current{\(\delta agnitude\)}			
name \current	base A	derived A	alternate A
$\verb \currentdensity \{ (magnit \\ \verb \currentdensity \} \{ (magnit \\ \verb \currentdensity \} \{ (magnit \\ \verb \currentdensity \} \} \} \} \} \} \} \} \} \}$			
name \currentdensity	base m ⁻² ·A	derived C·s/m²	alternate A/m²

\langle ma	gnitude angle brace		
name \dielectricconstant	base	derived	alternate
$\label{lem:displacement} $$\operatorname{\colored}_{\colored} $$\operatorname{\colored}_{\colored} $$\operatorname{\colored}_{\colored} $$$			
${ m name}$	base m	derived m	alternate m
\duration{\(magnitude \) \}			
name \duration	base s	derived s	alternate s
(n			
name	base m·s·A	derived C∙m	alternate C·m
$\verb \electricfield{ (magnitual vectorelectricfield{ (c_1 + c_2) } }$			
name	$\begin{array}{c} base \\ m \cdot kg \cdot s^{-3} \cdot A^{-1} \end{array}$	derived V/m	alternate N/C
\(magnitude\)) }		
name \electricflux	$\begin{array}{c} base \\ m^3 \cdot kg \cdot s^{-3} \cdot A^{-1} \end{array}$	derived V·m	alternate N·m²/C
\(mag	$nitude$ }}		
name \electricpotential	$\begin{array}{c} base \\ m^2 \cdot kg \cdot s^{-3} \cdot A^{-1} \end{array}$	derived V	alternate J/C
\(\dagnit\)	tude)}		
name \electroncurrent	$\begin{array}{c} \text{base} \\ \text{s}^{-1} \end{array}$	derived e/s	alternate e/s
$\ensuremath{\mbox{emf}\{\langle magnitude \rangle\}}$			
name \emf	$\begin{array}{c} {\rm base} \\ {\rm m^2 \cdot kg \cdot s^{-3} \cdot A^{-1}} \end{array}$	derived V	alternate J/C

\energy{(magnitude)}			
,			
name	base	derived	alternate
\energy	$m^2 \cdot kg \cdot s^{-2}$	J	J
\(magnitude \)	<pre>>>}</pre>		
name	base	derived	alternate
\energydensity	m ⁻¹ ·kg·s ⁻²	J/m ³	J/m ³
\	-		
\energyflux{ $\langle magnitude \rangle$ } \vectorenergyflux{ $\langle c_1, \dots, c_n \rangle$ }	(c_m)		
(,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,			
name	base	derived	alternate
\energyflux	kg⋅s ⁻³	W/m ²	W/m ²
$\ensuremath{\mbox{entropy}} \ensuremath{\mbox{(}magnitude\ensuremath{\mbox{)}}}$			
			•
name \entropy	base m²·kg·s ⁻² ·K ⁻¹	derived J/K	alternate J/K
(епстору	III 'NG'S 'N	J/K	J/K
\force{\langle magnitude \rangle}			
$\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ $			
name	base	derived	alternate
\force	$\text{m} \cdot \text{kg} \cdot \text{s}^{-2}$	N	N
\frequency{\((magnitude\)\)}			
name	base	derived	alternate
\frequency	s^{-1}	Hz	Hz
$\verb \gravitationalfield{ } \langle mag$			
\vectorgravitationalfiel	$\mathbf{d}\{\langle c_1,\dots,c_n\rangle\}$		
name	base	derived	alternate
\gravitationalfield	m·s ⁻²	N/kg	N/kg
	(maanitude\}		
(gravitationalpotonulai)	(magnitudae)		
name	base	derived	alternate
\gravitationalpotential	$m^2 \cdot s^{-2}$	J/kg	J/kg
\impulse{\langle magnitude \range}			
$\verb \vectorimpulse{ \langle c_1,\dots,c_n\rangle } $	ł die		

name \impulse	$\begin{array}{c} {\rm base} \\ {\rm m\cdot kg\cdot s^{-1}} \end{array}$	derived N·s	
\indexofrefraction{\language}	$vitude$ }}		
name	base	derived	alternate
\inductance {\langle magnitude \rangle}			
name	base m ² ·kg·s ⁻² ·A ⁻²	derived H	alternate V·s/A
\(maximum \)	ignitude)}		
name	base m ⁻¹ ·s·A	derived C/m	alternate C/m
\(magn	ntuae)}		
${\rm name} \\ {\tt linearmassdensity}$	base m ⁻¹ ⋅kg	derived kg/m	alternate kg/m
$\label{luminous} \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \$			
name \luminous	base cd	derived cd	$ \begin{array}{c} \text{alternate} \\ \text{cd} \end{array} $
\(magnitue \)	<i>le</i> }}		
name \magneticcharge	base m·A	$_{m\cdot A}^{\mathrm{derived}}$	$\underset{m\cdot A}{\operatorname{alternate}}$
(magneticdipolemoment)			
$name \\ \verb \magneticdipolemoment \\$	base m²·A		alternate J/T
$\label{local_magnetic} $$ \mbox{$\operatorname{Magnitude}$} \ \ \mbox{$\operatorname{Commagneticfield}(c_1, c_2)$} $$ $$ \mbox{$\operatorname{Commagneticfield}(c_2, c_3)$} $$ $$ $\mbox{$\operatorname{Commagneticfield}(c_2, c_3)$} $$ $$ $$ \mbox{$\operatorname{Commagneticfield}(c_3, c_3)$} $$ $$ \operatorname			
name \magneticfield	$\begin{array}{c} \text{base} \\ \text{kg} \cdot \text{s}^{-2} \cdot \text{A}^{-1} \end{array}$	derived T	$\begin{array}{c} \mathrm{alternate} \\ \mathrm{N/C} \cdot (\mathrm{m/s}) \end{array}$
$\mbox{\mbox{$\mbox{magneticflux}{$\mbox{$\m$	}		

name \magneticflux	$\begin{array}{c} {\rm base} \\ {\rm m^2 \cdot kg \cdot s^{-2} \cdot A^{-1}} \end{array}$		
$\mbox{\mbox{$\mbox{mass}${\langle magnitude\rangle$}}}$			
name \mass	base kg	derived kg	$_{\rm kg}^{\rm alternate}$
<pre>\mobility{(magnitude)}</pre>			
name \mobility	base m ² ·kg·s ⁻⁴ ·A ⁻¹	derived m²/V·s	$\begin{array}{c} {\rm alternate} \\ {(m/s)/(N/C)} \end{array}$
\momentofinertia{\dagnita}	$ude angle \}$		
name \momentofinertia	base m²·kg	derived J·s²	$_{\rm kg\cdot m^2}^{\rm alternate}$
$\label{local_magnitude} $$\operatorname{Local}(a_1,\dots,c_n) = (c_1,\dots,c_n) $$$)}		
name \momentum	base m·kg·s ⁻¹	derived N·s	$\underset{\text{kg} \cdot \text{m/s}}{\text{alternate}}$
$\label{local_momentumflux} $$\operatorname{magnitude}$ \\ \operatorname{momentumflux}(c_1, \ldots, c_n) $$$			
name \momentumflux	$\begin{array}{c} base \\ m^{-1} \cdot kg \cdot s^{-2} \end{array}$	derived N/m²	$\begin{array}{c} {\rm alternate} \\ {\rm N/m^2} \end{array}$
\(magnitude \)	e > }		
name \numberdensity	$_{\rm m^{-3}}^{\rm base}$	derived /m³	$_{/m^3}^{\rm alternate}$
\permeability {\(\text{magnitude}\)	}		
${\rm name} \\ {\tt \backslash permeability}$	$\begin{array}{c} base \\ m \cdot kg \cdot s^{-2} \cdot A^{-2} \end{array}$	derived T·m/A	alternate H/m
(magnitude)	,}		
name	$\begin{array}{c} \text{base} \\ \text{m}^{-3} {\cdot} \text{kg}^{-1} {\cdot} \text{s}^{-4} {\cdot} \text{A}^2 \end{array}$	derived F/m	alternate $C^2/N \cdot m^2$
$\verb \planeangle{ } (magnitude) $			

name \planeangle	$\begin{array}{c} {\rm base} \\ {\rm m\cdot m^{-1}} \end{array}$	derived rad	alternate rad
\(magnitu	$de\rangle$		
name \polarizability	base $kg^{-1} \cdot s^4 \cdot A^2$	$\begin{array}{c} \mathrm{derived} \\ C{\cdot}m^2/V \end{array}$	$\begin{array}{c} {\rm alternate} \\ {\rm C\cdot m/(N/C)} \end{array}$
$\power{\langle magnitude \rangle}$			
name \power	base m²·kg·s⁻³	derived W	alternate J/s
$\begin{tabular}{ll} $$ \operatorname{poynting}((magnitude)) \\ $\ \operatorname{c}_1,\ldots,c_r. \\ \end{tabular}$	<i>₁</i> ⟩}		
name \poynting	base kg·s ⁻³	derived W/m²	alternate W/m²
\pressure{\langle magnitude \range}			
name \pressure	base $m^{-1} \cdot kg \cdot s^{-2}$	derived Pa	alternate N/m²
</td <td>$nagnitude \}$</td> <td></td> <td></td>	$nagnitude \} $		
${ m name}$	base	derived	alternate
</td <td>$nagnitude angle \}$</td> <td></td> <td></td>	$nagnitude angle \}$		
${ m name}$	base	derived	alternate
\resistance{\(\dagmagnitude\)}			
name \resistance	$\begin{array}{c} {\rm base} \\ {\rm m^2 \cdot kg \cdot s^{-3} \cdot A^{-2}} \end{array}$	derived V/A	$_{\Omega}^{\rm alternate}$
\resistivity{\(magnitude\)}	}		
name \resistivity	$\begin{array}{c} {\rm base} \\ {\rm m^3 \cdot kg \cdot s^{-3} \cdot A^{-2}} \end{array}$	$\operatorname*{derived}_{\Omega\cdot m}$	$\begin{array}{c} {\rm alternate} \\ {\rm (V/m)/(A/m^2)} \end{array}$
\solidangle{\((magnitude\))}			
name \solidangle	base $m^2 \cdot m^{-2}$	derived sr	alternate sr

\(magnetite{ma	$nitude$ }}		
name \specificheatcapacity	$\begin{array}{c} \text{base} \\ \text{m}^2 \cdot \text{s}^{-2} \cdot \text{K}^{-1} \end{array}$	derived J/K·kg	alternate J/K·kg
\(\dagmagnitude\))}		
name \springstiffness	base kg·s ⁻²	derived N/m	alternate N/m
\springstretch{(magnitude)}			
name \springstretch	base m	derived m	alternate m
\stress{\(magnitude\)}			
name \stress	$\begin{array}{c} {\rm base} \\ m^{-1} {\cdot} kg {\cdot} s^{-2} \end{array}$	derived Pa	alternate N/m²
\strain{\(magnitude\)}			
name \strain	base	derived	alternate
\temperature{\langle magnitude \rangle}			
name \temperature	base K	derived K	alternate K
$\label{eq:loss_torque} $$ \operatorname{cque}(\operatorname{magnitude}) $$ \operatorname{cque}(c_1,\dots,c_n) $$$			
name \torque	base m ² ·kg·s ⁻²	derived N·m	alternate N·m
$\label{eq:continuity} $$ \end{area} $$ \en$			
name \velocity	$\begin{array}{c} {\rm base} \\ {\rm m\cdot s^{-1}} \end{array}$	$_{\text{m}\cdot \text{s}^{-1}}^{\text{derived}}$	alternate m/s
name \velocityc	base c	derived	$_{\rm c}^{\rm alternate}$

\volume{(magnitude)}			
name \volume	base m ³	derived m ³	
(ma	$gnitude$ }}		
${\rm name} \\ \verb \volumechargedensity $	base m ⁻³ ·s·A	derived C/m ³	$\begin{array}{c} \text{alternate} \\ \text{C/m}^3 \end{array}$
(magn	$itude$ }}		
${\rm name} \\ {\tt \volumemassdensity}$	base m ⁻³ ·kg	derived kg/m³	alternate kg/m ³
$\wedge \mbox{\wavelength} \mbox{\wavelength} \mbox{\wedge} \mbox{\wedge}$			
name \wavelength	base m	derived m	alternate m
$\label{eq:local_magnitude} $$ \operatorname{magnitude} \ \ \operatorname{c}_1, \dots, \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \$	c_n >}		
name \wavenumber	$_{\rm m^{-1}}^{\rm base}$	derived /m	alternate /m
$\work{\langle magnitude \rangle}$			
name \work \youngsmodulus{\magnitude}	base m ² ·kg·s ⁻²	derived J	alternate N·m
name \youngsmodulus	base m ⁻¹ ·kg·s ⁻²	derived Pa	alternate N/m²

2.1.4 Defining Your Own Physical Quantities

It is important to *not* define a quantity with the same name using *both* \newscalarquantity and \newvectorquantity because the latter automatically defines both scalar and vector variants. For example in the case of \momentum $^{-P.7}$ both \momentum and \vectormomentum are defined. The scalar variant is useful for typesetting magnitudes.

N 2021-02-16

\newscalarquantity{(name)}{(base units)}[(derived units)][(alternate units)]

Command to define a new scalar quantity. If the derived or alternate units are omitted, they are defined to be the same as the base unit.

N 2021-02-16

\newvectorquantity{\((name\))} \[(\delta e units\)\] \[(\delta e units\)\] \[(\delta e units\)\]

Command to define a new vector quantity. If the derived or alternate units are omitted, they are defined to be the same as the base unit.

2.1.5 Setting Global Units

```
\alwaysusebaseunits
\alwaysusederivedunits
\alwaysusealternateunits
```

Modal commands (switches) for setting the default unit form for the entire document. When mandi is loaded, one of these three commands is executed depending on whether the optional units key is provided. See the section on loading the package for details. Alternate units are the default because they are the most likely ones to be seen in introductory physics textbooks.

2.1.6 Setting Units for a Single Instance

```
\hereusebaseunits{(content)}
\hereusederivedunits{(content)}
\hereusedalternateunits{(content)}
```

Commands for setting the unit form on the fly for a single instance. The example uses momentum and the Coulomb constant, but they work for any defined quantity and constant.

```
5\,\mathrm{m\cdot kg\cdot s^{-1}}
\hereusebaseunits{\momentum{5}}
                                                           11
                                                                                    5 N·s
\hereusederivedunits{\momentum{5}}
\hereusealternateunits{\momentum{5}}
                                                                                    5 \text{ kg} \cdot \text{m/s}
                                                          11
\hereusebaseunits{\oofpez}
                                                           //
                                                                                    9 \times 10^9 \,\mathrm{m}^3 \cdot \mathrm{kg} \cdot \mathrm{s}^{-4} \cdot \mathrm{A}^{-2}
\hereusederivedunits{\oofpez}
                                                           //
                                                                                    9\times10^9\,\mathrm{m/F}
\hereusealternateunits{\oofpez}
                                                                                    9 \times 10^9 \, \text{N} \cdot \text{m}^2/\text{C}^2
```

2.1.7 Setting Units in an Environment

Inside these environments units are changed for the duration of the environment regardless of the global default setting.

```
\momentum{5}
\oofpez
                         //
\begin{usebaseunits}
                                                                                         5 \text{ kg} \cdot \text{m/s}
                                                                                         9\times 10^9\,\text{N}{\cdot}\text{m}^2/\text{C}^2
   \momentum{5} \\
   \oofpez
                                                                                         5 \,\mathrm{m\cdot kg\cdot s^{-1}}
\end{usebaseunits}
                                                                                         9 \times 10^9 \,\mathrm{m}^3 \cdot \mathrm{kg} \cdot \mathrm{s}^{-4} \cdot \mathrm{A}^{-2}
\begin{usederivedunits}
   \momentum{5} \\
   \oofpez
                                                                                         9 \times 10^{9} \, \text{m/F}
\end{usederivedunits}
                                                                                         5 \,\mathrm{kg \cdot m/s}
\begin{usealternateunits}
                                                                                         9\times 10^9\,\text{N}{\cdot}\text{m}^2/\text{C}^2
   \mbox{momentum{5} }
   \oofpez
\end{usealternateunits}
```

2.2 Physical Constants

2.2.1 Typesetting Physical Constants

Take the quantity $\frac{1}{4\pi\epsilon_o}$, sometimes called the Coulomb constant, as the prototypical physical constant in an introductory physics course. Here are all the ways to access this quantity in mandi. As you can see, these commands are almost identical to the corresponding commands for physical quantities.

\oofpez

Command for the Coulomb constant. The constant's numerical precision and default units will depend on the options passed to mandi at load time. Alternate units and approximate numerical values are the defaults. Other units can be forced as demonstrated.

```
9 \times 10^9 \, \text{N} \cdot \text{m}^2/\text{C}^2
                                                                                       9 \times 10^9
\oofpezapproximatevalue
                                                                                       8.987551787 \times 10^9
\oofpezprecisevalue
\oofpezmathsymbol
                                                                                       9 \times 10^9 \,\mathrm{m}^3 \cdot \mathrm{kg} \cdot \mathrm{s}^{-4} \cdot \mathrm{A}^{-2}
\oofpezbaseunits
\oofpezderivedunits
                                                                                       9 \times 10^9 \, \text{m/F}
\oofpezalternateunits
                                                                                       9 \times 10^9 \, \text{N} \cdot \text{m}^2 / \text{C}^2
\oofpezonlybaseunits
                                                                                       m^3 \cdot kg \cdot s^{-4} \cdot A^{-2}
\oofpezonlyderivedunits
\oofpezonlyalternateunits
                                                                                       N \cdot m^2 / C^2
```

2.2.2 Checking Physical Constants

N 2021-02-16

Command to check and typeset the constant's name, base units, derived units, alternate units, mathematical symbol, approximate value, and precise value.

2.2.3 Commands For Predefined Physical Constants

Every other defined physical constant can be treated similarly. Just replace oofpez with the constant's name. Unfortunately, there is no universal agreement on the names of every constant so consult the next section for the names that have been used. Here are all the physical constants, with all their units, defined in mandi. The constants \coulombconstant $^{\rightarrow P.19}$ and \biotsavartconstant $^{\rightarrow P.19}$ are defined as semantic aliases for, respectively, \oofpez $^{\rightarrow P.22}$ and \mzofp $^{\rightarrow P.21}$.

	\avogadro			
	$\begin{array}{c} \text{name} \\ \texttt{\ \ } \texttt{avogadro} \\ \text{symbol} \\ N_A \end{array}$	base mol^{-1} approximate 6×10^{23}	$\begin{array}{c} \text{derived} \\ \text{mol}^{-1} \\ \text{precise} \\ 6.022140857 \times 10^{23} \end{array}$	alternate mol ⁻¹
N 2021-02-02	\biotsavartconstant			
	name \\delta iotsavartconstant \\delta j mbol \\ \frac{\mu_o}{4\pi} \end{ar}	base $m \cdot kg \cdot s^{-2} \cdot A^{-2}$ approximate 10^{-7}	derived H/m precise 10 ⁻⁷	alternate T·m/A
	\bohrradius			
	$\begin{array}{c} \text{name} \\ \texttt{\bohrradius} \\ \text{symbol} \\ a_0 \end{array}$	base m approximate 5.3×10^{-11}	derived m precise $5.2917721067 \times 10^{-11}$	alternate m
	\boltzmann			
	$\begin{array}{c} \text{name} \\ \texttt{\boltzmann} \\ \text{symbol} \\ k_B \end{array}$	base $m^2 \cdot kg \cdot s^{-2} \cdot K^{-1}$ approximate 1.4×10^{-23}	derived J/K precise $1.38064852 \times 10^{-23}$	alternate J/K
N 2021-02-02	\coulombconstant			
	$\begin{array}{c} \text{name} \\ \texttt{\coulombconstant} \\ \text{symbol} \\ \frac{1}{4\pi\epsilon_o} \end{array}$	base $m^3 \cdot kg \cdot s^{-4} \cdot A^{-2}$ approximate 9×10^9	derived m/F precise $8.9875517873681764 \times 10^9$	alternate $N \cdot m^2/C^2$
	\earthmass			
	$\begin{array}{c} \text{name} \\ \texttt{\earthmass} \\ \text{symbol} \\ M_{\text{Earth}} \end{array}$	base kg approximate 6.0×10^{24}	derived kg precise 5.97237×10^{24}	alternate kg

\earthmoondistance			
$\begin{array}{c} \text{name} \\ \texttt{\ \ } \\ \texttt{\ \ } \\ \text{symbol} \\ \\ d_{\text{EM}} \end{array}$	base m approximate 3.8×10^8	derived m precise 3.81550 × 10 ⁸	alternate m
\earthradius			
$\begin{array}{c} \text{name} \\ \texttt{\ \ } \\ \text{symbol} \\ R_{\text{Earth}} \end{array}$	base m approximate 6.4×10^6	derived m precise 6.371×10^6	alternate m
\earthsundistance			
$\begin{array}{c} \text{name} \\ \texttt{\earthsundistance} \\ \text{symbol} \\ d_{\text{ES}} \end{array}$	base m approximate 1.5×10^{11}	derived m precise 1.496×10^{11}	alternate m
\electroncharge			
$\begin{array}{c} \text{name} \\ \texttt{\ \ } \\ \texttt{\ } \\ \texttt{\ } \\ \texttt{\ } \\ q_e \end{array}$	base A·s approximate -1.6×10^{-19}	derived C precise $-1.6021766208 \times 10^{-19}$	alternate C
\electronCharge			
$\begin{array}{c} \text{name} \\ \texttt{\ \ } \\ \texttt{\ } \\ \texttt{\ } \\ \texttt{\ } \\ Q_e \end{array}$	base A·s approximate -1.6×10^{-19}	derived C precise $-1.6021766208 \times 10^{-19}$	alternate C
\electronmass			
$\begin{array}{c} \text{name} \\ \texttt{\ \ } \\ \texttt{\ } \\ \text{symbol} \\ m_e \end{array}$	base kg approximate 9.1×10^{-31}	derived kg precise $9.10938356 \times 10^{-31}$	alternate kg
\elementarycharge			
$\begin{array}{c} \text{name} \\ \texttt{\ \ } \\ \texttt{\ } \\ \text{symbol} \\ e \end{array}$	base A·s approximate 1.6×10^{-19}	derived C precise $1.6021766208 \times 10^{-19}$	alternate C

\finestructure			
$\begin{array}{c} \text{name} \\ \texttt{\finestructure} \\ \text{symbol} \\ \alpha \end{array}$	base approximate $\frac{1}{137}$	derived precise $7.2973525664 \times 10^{-3}$	alternate
\hydrogenmass			
$\begin{array}{c} \text{name} \\ \texttt{\hydrogenmass} \\ \text{symbol} \\ m_H \end{array}$	base kg approximate 1.7×10^{-27}	derived kg precise $1.6737236 \times 10^{-27}$	alternate kg
\moonearthdistance			
$\begin{array}{c} \text{name} \\ \texttt{\moonearthdistance} \\ \text{symbol} \\ d_{\text{ME}} \end{array}$	base m approximate 3.8×10^8	derived m precise 3.81550×10^8	alternate m
\moonmass			
$\begin{array}{c} \text{name} \\ \texttt{\sc} \\ \text{symbol} \\ M_{\texttt{Moon}} \end{array}$	base kg approximate 7.3×10^{22}	derived kg precise 7.342×10^{22}	alternate kg
\moonradius			
$\begin{array}{c} \text{name} \\ \texttt{\sc}_{\texttt{moon}} \\ \text{symbol} \\ R_{\texttt{Moon}} \end{array}$	base m approximate 1.7×10^6	derived m precise 1.7371 × 10 ⁶	alternate m
\mzofp			
name \mzofp symbol	base approximate	derived precise	alternate
\neutronmass			
$\begin{array}{c} \text{name} \\ \texttt{\neutronmass} \\ \text{symbol} \\ m_n \end{array}$	base kg approximate 1.7×10^{-27}	derived kg precise $1.674927471 \times 10^{-27}$	alternate kg

\oofpez			
name \oofpez symbol $\frac{1}{4\pi\epsilon_o}$	base $m^3 \cdot kg \cdot s^{-4} \cdot A^{-2}$ approximate 9×10^9	derived m/F precise 8.987551787 × 10 ⁹	alternate $N \cdot m^2/C^2$
\oofpezcs			
name \oofpezcs symbol $\frac{1}{4\pi\epsilon_o c^2}$	base $m \cdot kg \cdot s^{-2} \cdot A^{-2}$ approximate 10^{-7}	derived $T \cdot m^2$ precise 10^{-7}	alternate $N \cdot s^2/C^2$
\planck			
name \planck symbol h	base $m^2 \cdot kg \cdot s^{-1}$ approximate 6.6×10^{-34}	derived J·s precise $6.626070040 \times 10^{-34}$	alternate J·s
\planckbar			
name \planckbar symbol ħ	base $m^2 \cdot kg \cdot s^{-1}$ approximate 1.1×10^{-34}	derived J·s precise $1.054571800 \times 10^{-34}$	alternate J·s
1	_		
$egin{array}{l} \mathrm{name} \\ \mathbf{planckc} \\ \mathrm{symbol} \\ hc \end{array}$	base $m^3 \cdot kg \cdot s^{-2}$ approximate 2.0×10^{-25}	derived J·m precise 1.98644568 × 10 ⁻²⁵	alternate J·m
\protoncharge			
$\begin{array}{c} \text{name} \\ \texttt{\protoncharge} \\ \text{symbol} \\ q_p \end{array}$	base A·s approximate $+1.6 \times 10^{-19}$	derived C precise $+1.6021766208 \times 10^{-19}$	alternate C
\protonCharge			
$\begin{array}{c} \text{name} \\ \texttt{\protonCharge} \\ \text{symbol} \\ Q_p \end{array}$	base A·s approximate $+1.6 \times 10^{-19}$	derived C precise $+1.6021766208 \times 10^{-19}$	alternate C

\protonmass			
\protonmass			
$\begin{array}{c} \text{name} \\ \texttt{\protonmass} \\ \text{symbol} \\ m_p \end{array}$	base kg approximate 1.7×10^{-27}	derived kg precise $1.672621898 \times 10^{-27}$	alternate kg
\rydberg			
$\begin{array}{c} \text{name} \\ \texttt{\t rydberg} \\ \text{symbol} \\ R_{\scriptscriptstyle \infty} \end{array}$	base m^{-1} approximate 1.1×10^{7}	derived m^{-1} precise $1.0973731568508 \times 10^{7}$	
\speedoflight			
$\begin{array}{c} \text{name} \\ \texttt{\speedoflight} \\ \text{symbol} \\ c \end{array}$	base $m \cdot s^{-1}$ approximate 3×10^8	derived m/s precise 2.99792458×10^8	alternate m/s
\stefanboltzmann			
$\begin{array}{c} \text{name} \\ \texttt{\stefanboltzmann} \\ \text{symbol} \\ \sigma \end{array}$	base $kg \cdot s^{-3} \cdot K^{-4}$ approximate 5.7×10^{-8}	derived $W/m^2 \cdot K^4$ precise 5.670367×10^{-8}	alternate W/m ² ·K ⁴
\sunearthdistance			
$\begin{array}{c} \text{name} \\ \texttt{\sunearthdistance} \\ \text{symbol} \\ d_{\texttt{SE}} \end{array}$	base m approximate 1.5×10^{11}	derived m precise 1.496×10^{11}	alternate m
\sunradius			
$\begin{array}{c} \text{name} \\ \texttt{\setminus sunradius} \\ \text{symbol} \\ R_{\texttt{Sun}} \end{array}$	base m approximate 7.0×10^8	derived m precise 6.957×10^8	alternate m
\surfacegravfield			
$\begin{array}{c} \text{name} \\ \texttt{\surfacegravfield} \\ \text{symbol} \\ g \end{array}$	base $m \cdot s^{-2}$ approximate 9.8	derived N/kg precise 9.807	alternate N/kg

acuumpermeability			
name	base	derived	alternate
\vacuumpermeability	$\text{m}\cdot\text{kg}\cdot\text{s}^{-2}\cdot\text{A}^{-2}$	H/m	T·m/A
symbol	approximate	precise $4\pi \times 10^{-7}$	
μ_o	$4\pi \times 10^{-7}$	$4\pi \times 10^{-7}$	
vacuumpermittivity			

name base derived alternate vacuumpermittivity $m^{-3} \cdot kg^{-1} \cdot s^4 \cdot A^2$ F/m $C^2/N \cdot m^2$ symbol approximate precise $\epsilon_o \qquad 9 \times 10^{-12} \qquad 8.854187817 \times 10^{-12}$

2.2.4 Defining Your Own Physical Constants

N 2021-02-16

\newphysicalconstant{\(\(\angle\)\)}{\(\angle\)}{\(\an

Command to define a new physical constant. If the derived and alternate units are omitted, they are defined to be the same as the base units.

2.2.5 Setting Global Precision

N 2021-02-16 N 2021-02-16 \alwaysuseapproximateconstants \alwaysusepreciseconstants

Modal commands (switches) for setting the default precision for the entire document. The default with the package is loaded is set by the presence or absence of the preciseconstants $\stackrel{\rightarrow}{\sim} P.6$ key.

2.2.6 Setting Precision for a Single Instance

N 2021-02-16 N 2021-02-16 Commands for setting the precision on the fly for a single instance.

2.2.7 Setting Precision in an Environment

N 2021-02-16

N 2021-02-16

Inside these environments precision is changed for the duration of the environment regardless of the global default setting.

3 GlowScript and VPython Program Listings

3.1 The glowscriptblock Environment

U 2021-02-11

```
\begin{glowscriptblock} [\langle options \rangle] (\langle link \rangle) \langle (caption \rangle) \\ end{glowscriptblock}
```

Code placed here is nicely formatted and optionally linked to its source on GlowScript.org. Clicking anywhere in the code window will open the link in the default browser. A caption is mandatory, and a label is internally generated. The listing always begins on a new page. A URL shortening utility is recommended to keep the URL from getting unruly. For convenience, https:// is automatically prepended to the URL and can thus be omitted.

```
\begin{glowscriptblock}(tinyurl.com/y3lnqyn3){A short \texttt{GlowScript} Program}
GlowScript 3.0 vpython
scene.width = 400
scene.height = 760
# constants and data
g = 9.8  # m/s^2
mball = 0.03 # kg
Lo = 0.26 # m
ks = 1.8 # N/m
deltat = 0.01 # s
# objects (origin is at ceiling)
ceiling = box(pos=vector(0,0,0), length=0.2, height=0.01,
              width=0.2)
ball = sphere(pos=vector(0,-0.3,0),radius=0.025,
              color=color.orange)
spring = helix(pos=ceiling.pos, axis=ball.pos-ceiling.pos,
               color=color.cyan,thickness=0.003,coils=40,
               radius=0.010)
# initial values
pball = mball * vector(0,0,0)
                                # kg m/s
Fgrav = mball * g * vector(0,-1,0) # N
t = 0
# improve the display
scene.autoscale = False
                              # turn off automatic camera zoom
scene.center = vector(0,-Lo,0) # move camera down
scene.waitfor('click')
                             # wait for a mouse click
# initial calculation loop
# calculation loop
while t < 10:
   rate(100)
    # we need the stretch
    s = mag(ball.pos) - Lo
    # we need the spring force
    Fspring = ks * s * -norm(spring.axis)
    Fnet = Fgrav + Fspring
    pball = pball + Fnet * deltat
    ball.pos = ball.pos + (pball / mball) * deltat
    spring.axis = ball.pos - ceiling.pos
    t = t + deltat
\end{glowscriptblock}
```

GlowScript Program 1: A short GlowScript program 1 GlowScript 3.0 vpython scene.width = 4003 scene.height = 7604 # constants and data g = 9.8# m/s^2 mball = 0.03 # kgLo = 0.26 # m ks = 1.8# N/m **deltat = 0.01** # s 10 11 # objects (origin is at ceiling) 12 ceiling = box(pos=vector(0,0,0), length=0.2, height=0.01,13 width=0.2) 14 ball = sphere(pos=vector(0,-0.3,0), radius=0.025, color=color.orange) 16 17 spring = helix(pos=ceiling.pos, axis=ball.pos-ceiling.pos, color=color.cyan,thickness=0.003,coils=40, 18 radius=**0.010**) 19 20 # initial values 21 pball = mball * vector(0,0,0)# kg m/s 22 Fgrav = mball * g * vector(0,-1,0) # N 23 25 # improve the display 26 scene.autoscale = False # turn off automatic camera zoom 27 scene.center = vector(0, -Lo, 0) # move camera down 28 scene waitfor('click') # wait for a mouse click 30 # initial calculation loop 31 # calculation loop 32 while t < 10: 33 rate(100) 34 # we need the stretch 35 s = mag(ball.pos) - Lo36 # we need the spring force 37 Fspring = ks * s * -norm(spring.axis) 38 Fnet = Fgrav + Fspring 39 pball = pball + Fnet * deltat 40 ball.pos = ball.pos + (pball / mball) * deltat 41 spring.axis = ball.pos - ceiling.pos 42 t = t + deltat43

```
\GlowScript\ program \ref{gs:1} is nice. It's called \nameref{gs:1} and is on page \pageref{gs:1}.

GlowScript program 1 is nice. It's called A short GlowScript program and is on page 27.
```

3.2 The vpythonfile Command

U 2021-02-11

\vpythonfile[\langle options \rangle] \{\langle file \rangle \} \{\langle caption \rangle \}

Command to load and typeset a VPython program. The file is read from $\{\langle file \rangle\}$. Clicking anywhere in the code window can optionally open a link, passed as an option, in the default browser. A caption is mandatory, and a label is internally generated. The listing always begins on a new page. A URL shortening utility is recommended to keep the URL from getting unruly. For convenience, https:// is automatically prepended to the URL and can thus be omitted.

VPython Program 1: A VPython program from vpython import * scene.width = 4003 scene.height = 7604 # constants and data 6 g = 9.8# m/s^2 mball = 0.03 # kgLo = 0.26 # m ks = 1.8# N/m deltat = 0.01 # s11 # objects (origin is at ceiling) 12 ceiling = box(pos=vector(0,0,0), length=0.2, height=0.01,13 width=0.2) 14 ball = sphere(pos=vector(0,-0.3,0), radius=0.025, color=color.orange) 16 17 spring = helix(pos=ceiling.pos, axis=ball.pos-ceiling.pos, color=color.cyan,thickness=0.003,coils=40, 18 radius=0.010) 19 20 # initial values 21 pball = mball * vector(0,0,0)# kg m/s 22 Fgrav = mball * g * vector(0,-1,0) # N 23 25 # improve the display 26 # turn off automatic camera zoom scene.autoscale = False 27 scene.center = vector(0, -Lo, 0) # move camera down 28 scene waitfor('click') # wait for a mouse click 30 # initial calculation loop 31 # calculation loop 32 while t < 10: 33 rate(100) 34 # we need the stretch 35 s = mag(ball.pos) - Lo36 # we need the spring force 37 Fspring = ks * s * -norm(spring.axis) 38 39 Fnet = Fgrav + Fspringpball = pball + Fnet * deltat 40 ball.pos = ball.pos + (pball / mball) * deltat 41 spring.axis = ball.pos - ceiling.pos 42 t = t + deltat43

```
\text{VPython\ program \ref{vp:1} is nice. It's called \nameref{vp:1} and is on page \pageref{vp:1}.}

VPython program 1 is nice. It's called A VPython program and is on page 29.
```

3.3 The glowscriptinline and vpythoninline Commands

```
U 2021-02-15
U 2021-02-15
```

```
\glowscriptinline{\langle GlowScript code \rangle}
\vpythoninline{\langle VPython code \rangle}
```

Typesets a small, in-line snippet of code. The snippet should be less than one line long.

```
\GlowScript\ programs begin with \glowscriptinline{GlowScript 3.0 VPython} and \VPython\ programs begin with \vpythoninline{from vpython import *}.

GlowScript programs begin with GlowScript 3.0 VPython and VPython programs begin with from vpython import *.
```

4 Commands for Writing Physics Problem Solutions

4.1 Introductory Needs

mandi provides a collection of commands physics students can use for writing problem solutions. This new version focuses on the most frequently needed tools. These commands should always be used in math mode.

4.1.1 Traditional Vector Notation

```
\ensuremath{\vec{\langle symbol\rangle}[\langle labels\rangle]} (use this variant for boldface notation) 
\ensuremath{\vec*{\langle symbol\rangle}[\langle labels\rangle]} (use this variant for arrow notation)
```

Powerful and intelligent command for symbolic vector notation. The mandatory argument is the symbol for the vector quantity. The optional label(s) consists of superscripts and/or subscripts and can be mathematical or textual in nature. If textual, be sure to wrap them in \symup{...} for proper typesetting. The starred variant gives arrow notation whereas without the star you get boldface notation. Subscript and superscript labels can be arbitrarily mixed, and order doesn't matter.

```
\zerovec (use this variant for boldface notation)
\zerovec* (use this variant for arrow notation)
```

Command for typesetting the zero vector. The starred version gives arrow notation whereas without the star you get boldface notation.

```
\(\zerovec \)\\\(\zerovec*\)
```

```
\Dvec{\(symbol\)} \( \text{use this variant for boldface notation} \)
\( \text{\(symbol\)} \)
\( \text{use this variant for arrow notation} \)
```

Command for typesetting the change in a vector. The starred variant gives arrow notation whereas without the star you get boldface notation. Subscript and superscript labels are not yet supported so if you need the symbol for the change in a subscripted or superscripted vector, just put \changein in front of it. This command must be used in math mode.

```
\(\Dvec{r}\\)\\\\(\Dvec*{r}\\)
```

```
\dirvec{\langle symbol\rangle} \(\text{use this variant for boldface notation}\)
\dirvec*{\langle symbol\rangle} \(\text{use this variant for arrow notation}\)
```

Command for typesetting the direction of a vector. The starred variant gives arrow notation whereas without the star you get boldface notation. Subscript and superscript labels are not yet supported.

```
\( \dirvec{r} \) \\ \( \dirvec*{r} \) \widehat{r}
```

```
\magvec{\symbol\} (use this variant for boldface notation)
\magvec*{\symbol\} (use this variant for arrow notation)
```

Command for type setting the magnitude of a vector. The starred variant gives arrow notation whereas without the star you get boldface notation. Subscript and superscript labels are not yet supported.

```
\(\magvec{r}\)\\\\(\magvec*{r}\)
```

$\mbox{\mbox{\mbox{$\backslash$}}} (delimiter)] {\langle c_1, \dots, c_n \rangle} [\langle units \rangle]$

Typesets a vector as either numeric or symbolic components with an optional unit (for numerical components only). There can be more than three components. The delimiter used in the list of components can be specified; the default is a comma. The notation mirrors that of *Matter & Interactions*.

```
\label{eq:continuous_policy} $$ \min \end{array} $$ \min \end
```

4.1.2 Coordinate-Free and Index Notation

Beyond the current level of introductory physics, we need intelligent commands for typesetting vector and tensor symbols and components suitable for both coordinate-free and index notations.

```
\veccomp\{\symbol\}\ (use this variant for coordinate-free vector notation)
\veccomp*\{\symbol\}\ (use this variant for index vector notation)
\tencomp\{\symbol\}\ (use this variant for coordinate-free tensor notation)
\tencomp*\{\symbol\}\ (use this variant for index tensor notation)
```

Conforms to ISO 80000-2 notation.

```
\(\veccomp{r}\)\\
\(\veccomp*{r}\)\\
r\\(\tencomp{r}\)\\
r\\(\tencomp*{r}\)\\
r
```

4.1.3 Problems and Annoted Problem Solutions

N 2021-02-03

N 2021-02-03

Provides an environment for stating physics problems. Each problem will begin on a new page. See the examples for how to handle single and multiple part problems.

```
\begin{physicsproblem}{Problem 1}
This is a physics problem with no parts.
\end{physicsproblem}

Problem 1

This is a physics problem with no parts.
```

```
\begin{physicsproblem}{Problem 2}
This is a physics problem with multiple parts.
The list is vertical.
\begin{parts}
  \problempart This is the first part.
  \problempart This is the second part.
  \problempart This is the third part.
  \end{parts}
\end{parts}
\end{physicsproblem}
```

Problem 2

This is a physics problem with multiple parts. The list is vertical.

- (a) This is the first part.
- (b) This is the second part.
- (c) This is the third part.

```
\begin{physicsproblem*}{Problem 3}
  This is a physics problem with multiple parts.
  The list is in-line.
  \begin{parts}
    \problempart This is the first part.
    \problempart This is the second part.
    \problempart This is the third part.
  \end{parts}
\end{parts}
\end{physicsproblem*}
```

Problem 3

This is a physics problem with multiple parts. The list is in-line. (a) This is the first part. (b) This is the second part. (c) This is the third part.

U 2021-02-02

U 2021-02-02

This environment is only for mathematical solutions. The starred variant omits numbering of steps. See the examples.

```
(1)
                                                                          x = y + z
\begin{physicssolution}
 x &= y + z \\
                                                                                                    (2)
                                                                          z = x - y
 z &= x - y \\
                                                                          y = x - z
                                                                                                    (3)
 y &= x - z
\end{physicssolution}
\begin{physicssolution*}
 x &= y + z \\
 z &= x - y \\
                                                                          x = y + z
 y &= x - z
\end{physicssolution*}
                                                                          z = x - y
                                                                          y = x - z
```

U 2012-02-02

\reason{\(\text{reason}\)}

Provides an annotation in a step-by-step solution. Keep reasons short and to the point. Wrap mathematical content in math mode.

```
(4)
                                                                x = y + z
                                                                              This is a reason.
\begin{physicssolution}
  x \&= y + z \geq \{This is a reason.\}
                                                                                                                 (5)
                                                                z = x - y
                                                                              This is a reason too.
  z &= x - y \cdot (This is a reason too.) \ y &= x - z \reason{final answer}
                                                                                                                 (6)
                                                                y = x - z
                                                                              final answer
\end{physicssolution}
\begin{physicssolution*}
  x &= y + z \reason{This is a reason.}
  z &= x - y \reason{This is a reason too.} \\
y &= x - z \reason{final answer}
                                                                 x = y + z
                                                                                This is a reason.
\end{physicssolution*}
                                                                 z = x - y
                                                                                 This is a reason too.
                                                                 y = x - z
                                                                                 final answer
```

When writing solutions, remember that the physics solution $^{\rightarrow P.33}$ environment is *only* for mathematical content, not textual content or explanations.

```
\begin{physicsproblem}{Combined Problem and Solution}

This is an interesting physics problem.
\begin{physicssolution}

The solution goes here.
\end{physicssolution}

\end{physicsproblem}
```

```
\begin{physicsproblem}{Combined Multipart Problem with Solutions}
 This is a physics problem with multiple parts.
 \begin{parts}
   \problempart This is the first part.
      \begin{physicssolution}
       The solution goes here.
     \end{physicssolution}
    \problempart This is the second part.
      \begin{physicssolution}
       The solution goes here.
     \end{physicssolution}
    \problempart This is the third part.
      \begin{physicssolution}
       The solution goes here.
     \end{physicssolution}
 \end{parts}
\end{physicsproblem}
```

N 2021-02-06

Hilites the desired target, which can be an entire mathematical expression or a part thereof. The default color is magenta and the default shape is a rectangle.

```
(\Delta s)^{2} = -(\Delta t)^{2} + (\Delta x)^{2} + (\Delta y)^{2} + (\Delta z)^{2}
(\Delta s)^{2} = -(\Delta t)^{2} + (\Delta x)^{2} + (\Delta y)^{2} + (\Delta z)^{2}
(\Delta s)^{2} = -(\Delta t)^{2} + (\Delta x)^{2} + (\Delta y)^{2} + (\Delta z)^{2}
(\Delta s)^{2} = -(\Delta t)^{2} + (\Delta x)^{2} + (\Delta y)^{2} + (\Delta z)^{2}
(\Delta s)^{2} = -(\Delta t)^{2} + (\Delta x)^{2} + (\Delta y)^{2} + (\Delta z)^{2}
```

```
\begin{align*}
  \Dvec{p} &= \vec{F}_{\sumup{net}}\,\Delta t \\
  \hilite[orange]{\Dvec{p}}[circle] &= \vec{F}_{\symup{net}}\,\Delta t \\
  \Delta\vec{p} &= \hilite[yellow!50]{\vec{F}_{\symup{net}}}[rounded rectangle]\,\Delta t \\
  \Delta\vec{p} &= \vec{F}_{\symup{net}}\,\hilite[olive!50]{\Delta t}[rectangle] \\
  \Delta\vec{p} &= \hilite[cyan!50]{\vec{F}_{\symup{net}}\,\Delta t}[ellipse] \\
  \hilite{\Delta\vec{p}}[rectangle] &= \vec{F}_{\symup{net}}\,\Delta t\\
  \end{align*}
```

$$\Delta \mathbf{p} = \mathbf{F}_{\text{net}} \Delta t$$

U 2021-02-04

$\label{limited} $$ \sum_{(aption)} {\langle aption \rangle} {\langle label \rangle} {\langle image \rangle} $$$

Simplified interface for importing an image. The images are treated as floats, so they may not appear at the most logically intuitive place.

\image[scale=0.20]{example-image-1x1}{Image shown 20 percent actual size.}{reffig1}

1 imes 1(Grighad dam 2001-2000 kgs)

Figure 1: Image shown 20 percent actual size.

\image[scale=0.20,angle=45]{example-image-1x1}{Image shown 20 percent actual size and } \cdot\reffig1}



Figure 2: Image shown 20 percent actual size and rotated.

4.2 Intermediate and Advanced Needs

Typesets column vectors and row vectors as numeric or symbolic components. There can be more than three components. The delimiter used in the list of components can be specified; the default is a comma.

Typesets tensor valence. The starred variant typesets it horizontally.

```
\contraction{\langle slot, slot \rangle} \contraction*{\langle slot, slot \rangle}
```

Typesets tensor contraction in coordinate-free notation. There is no standard on this so we assert one here.

```
\slot[\langle vector \rangle]
\slot*[\langle vector \rangle]
```

An intelligent slot command for coordinate-free vector and tensor notation. The starred variants suppress the underscore.

```
\( (\slot) \) \\
\( (\slot[\vec{a}]) \) \\
\( (\slot*) \) \\
\( (\slot*[\vec{a}]) \) \\
( a)
```

4.3 Useful Math Commands

```
\tento{(number)}
\timestento{(number)}
\xtento{(number)}
```

Commands for powers of ten and scientific notation.

```
\tento{-4} \\
3\timestento{8} \\
3\xtento{8} \\
3 \times 10^8
3 \times 10^8
```

\changein

Semantic alias for \Delta.

```
(double bars)
\norm[\langle size \rangle] \{\langle quantity \rangle\}
                                                                                                             (double bars for fractions)
\norm*[\langle size \rangle] \{\langle quantity \rangle\}
\absv[\langle size \rangle] \{\langle quantity \rangle\}
                                                                                                                                (single bars)
                                                                                                              (single bars for fractions)
\absv*[\langle size \rangle] \{\langle quantity \rangle\}
\ags[\langle size \rangle] \{\langle quantity \rangle\}
                                                                                                                           (angle brackets)
                                                                                                         (angle brackets for fractions)
\ags*[\langle size \rangle] \{\langle quantity \rangle\}
\parentheses [\langle size \rangle] {\langle quantity\rangle}
                                                                                                                               (parentheses)
\parentheses*[\langle size \rangle] \{\langle quantity \rangle\}
                                                                                                             (parentheses for fractions)
\dimensionsof[\langle size \rangle] \{\langle quantity \rangle\}
                                                                                                                         (square brackets)
                                                                                                       (square brackets for fractions)
\dimensionsof*[\langle size \rangle] \{\langle quantity \rangle\}
(curly braces)
                                                                                                            (curly braces for fractions)
```

If no argument is given, a placeholder is provided. Sizers like \big,\Big,\bigg, and \Bigg can be optionally specified. Beginners are encouraged not to use them. See the mathtools package documentation for details.

```
\langle \; \cdot \; \rangle
                                                                                                        \langle a \rangle
  \[ \angs{} \]
  \[ \angs{\vec{a}} \]
                                                                                                        \left\langle \frac{a}{3} \right\rangle
  \[ \angs*{\frac{\vec{a}}{3}} \]
  \[ \ags[\Bigg]{\frac{\vec{a}}{3}} \]
                                                                                                        (·)
                                                                                                        (x)
  \[ \parentheses{} \]
  \[ \parentheses{x} \]
\[ \parentheses*{\frac{x}{3}} \]
                                                                                                        \left(\frac{x}{3}\right)
  \[ \parentheses[\Bigg]{\frac{x}{3}} \]
                                                                                                        [\cdot]
                                                                                                        [x]
  \[ \dimensionsof{} \]
  \[ \dimensionsof{x} \]
\[ \dimensionsof*{\frac{x}{3}} \]
                                                                                                        \left[\frac{x}{3}\right]
  {·}
                                                                                                        \{x\}
  \[ \unitsof{} \]
  \[ \unitsof{x} \]
  \[ \unitsof*{\frac{x}{3}} \]
\[ \unitsof[\Bigg]{\frac{x}{3}} \]
\dim
                                                                                                                   (defined in amsmath)
\abs
\units
```

Operators which may be more useful than delimiters.

5 Commands Specific to Matter & Interactions

mandi comes with an accessory package mandiexp which includes commands specific to *Matter & Interactions*². The commands are primarily for typesetting mathematical expressions used in the text. Use of mandiexp is optional and so must be manually loaded by including the line \usepackage{mandiexp} in your document's preamble.

5.1 The Momentum Principle

```
\LHSmomentumprinciple
                                                                 (LHS of delta form, bold vectors)
                                                                 (RHS of delta form, bold vectors)
\RHSmomentumprinciple
\LHSmomentumprincipleupdate
                                                                (LHS of update form, bold vectors)
\RHSmomentumprincipleupdate
                                                               (RHS of update form, bold vectors)
\momentumprinciple
                                                                         (delta form, bold vectors)
\momentumprincipleupdate
                                                                       (update form, bold vectors)
                                                                (LHS of delta form, arrow vectors)
\LHSmomentumprinciple*
\RHSmomentumprinciple*
                                                                (RHS of delta form, arrow vectors)
\LHSmomentumprincipleupdate*
                                                              (LHS of update form, arrow vectors)
\RHSmomentumprincipleupdate*
                                                              (RHS of update form, arrow vectors)
\momentumprinciple*
                                                                       (delta form, arrow vectors)
\momentumprincipleupdate*
                                                                      (update form, arrow vectors)
```

Variants of command for typesetting the momentum principle. Use starred variants to get arrow notation for vectors.

```
\Delta oldsymbol{p}_{	ext{svs}}
                                                                                                \mathbf{F}_{\text{sys,net}} \Delta t
\(\LHSmomentumprinciple\)
                                                               11
                                                                                                \boldsymbol{p}_{\text{sys,final}}
\(\RHSmomentumprinciple\)
                                                               //
                                                                                                \mathbf{p}_{\mathrm{sys,initial}} + \mathbf{F}_{\mathrm{sys,net}} \Delta t

\Delta \mathbf{p}_{\mathrm{sys}} = \mathbf{F}_{\mathrm{sys,net}} \Delta t
\(\LHSmomentumprincipleupdate\)
\(\RHSmomentumprincipleupdate\)
\(\momentumprinciple\)
                                                                                                p_{\text{sys,final}} = p_{\text{sys,initial}} + F_{\text{sys,net}} \Delta t
                                                               //
\(\momentumprincipleupdate\)
                                                                                                \Delta \overline{p}_{\mathrm{sys}}
\(\LHSmomentumprinciple*\)
                                                                                                \vec{F}_{\rm sys,net} \Delta t
\(\RHSmomentumprinciple*\)
\(\LHSmomentumprincipleupdate*\)
                                                                                                \vec{p}_{\text{sys,final}}
\(\RHSmomentumprincipleupdate*\)\\
                                                                                                \vec{p}_{\text{sys,initial}} + \vec{F}_{\text{sys,net}} \Delta t
\( \momentumprinciple* \)
                                                               11
\(\momentumprincipleupdate* \)
                                                                                                \Delta \vec{p}_{\text{sys}} = \vec{F}_{\text{sys,net}} \Delta t
                                                                                                \overrightarrow{p}_{\mathrm{sys,final}} = \overrightarrow{p}_{\mathrm{sys,initial}} + \overrightarrow{F}_{\mathrm{sys,net}} \, \Delta t
```

5.2 The Energy Principle

```
\LHS energyprinciple (LHS of delta form)
\RHSenergyprinciple[(+process...)] (RHS of delta form)
\LHSenergyprincipleupdate (LHS of update form)
```

²See Matter & Interactions and https://matterandinteractions.org/ for details

```
\RHSenergyprincipleupdate[\(\rho\) (RHS of update form) \
\energyprinciple[\(\rho\) (delta form) \
\energyprincipleupdate[\(\rho\) (update form)
```

Variants of command for typesetting the energy principle.

```
\Delta E_{\rm sys}
                                                                                       W_{\rm ext}
\(\LHSenergyprinciple\)
\(\RHSenergyprinciple\)
                                                                                       W_{\text{ext}} + Q
\(\RHSenergyprinciple[+Q]\)
                                                                                       \Delta E_{\rm sys} = W_{\rm ext}
\Delta E_{\rm sys} = W_{\rm ext} + Q
\( \energyprinciple \)
\( \energyprinciple[+Q] \)
\(\LHSenergyprincipleupdate\)
                                                                                       E_{\rm sys,final}
                                                                                      E_{\rm sys,final} = E_{\rm sys,initial} + W_{\rm ext}
E_{\rm sys,initial} + W_{\rm ext} + Q
E_{\rm sys,final} = E_{\rm sys,initial} + W_{\rm ext}
E_{\rm sys,final} = E_{\rm sys,initial} + W_{\rm ext} + Q
\(\RHSenergyprincipleupdate\)
\(\RHSenergyprincipleupdate[+Q]\)
\(\energyprincipleupdate\)
\(\energyprincipleupdate[+Q]\)
```

5.3 The Angular Momentum Principle

```
(LHS of delta form, bold vectors)
\LHSangularmomentumprinciple
\RHSangularmomentumprinciple
                                                                (RHS of delta form, bold vectors)
\LHSangularmomentumprincipleupdate
                                                              (LHS of update form, bold vectors)
\RHSangularmomentumprincipleupdate
                                                              (RHS of update form, bold vectors)
\angularmomentumprinciple
                                                                       (delta form, bold vectors)
                                                                      (update form, bold vectors)
\angularmomentumprincipleupdate
\LHSangularmomentumprinciple*
                                                               (LHS of delta form, arrow vectors)
\RHSangularmomentumprinciple*
                                                               (RHS of delta form, arrow vectors)
\LHSangularmomentumprincipleupdate*
                                                             (LHS of update form, arrow vectors)
\RHSangularmomentumprincipleupdate*
                                                             (RHS of update form, arrow vectors)
\angularmomentumprinciple*
                                                                      (delta form, arrow vectors)
\angularmomentumprincipleupdate*
                                                                    (update form, arrow vectors)
```

Variants of command for typesetting the angular momentum principle. Use starred variants to get arrow notation for vectors.

```
\Delta \mathbf{L}_{A, \mathrm{sys, net}}
                                                                                                    	au_{A, 	ext{sys,net}} \Delta t
                                                                                                    \mathbf{L}_{A, \mathrm{sys, final}}^{I, I, I}
\(\LHSangularmomentumprinciple\)
                                                                               //
\(\RHSangularmomentumprinciple\)
                                                                                                    \boldsymbol{L}_{A, \mathrm{sys,initial}} + \boldsymbol{\tau}_{A, \mathrm{sys,net}} \Delta t
\(\LHSangularmomentumprincipleupdate\)
                                                                               //
                                                                                                    \Delta \mathbf{L}_{A, \mathrm{sys, net}} = \boldsymbol{\tau}_{A, \mathrm{sys, net}} \Delta t
\(\RHSangularmomentumprincipleupdate\)
                                                                                                    \mathbf{L}_{A, \mathrm{sys, final}} = \mathbf{L}_{A, \mathrm{sys, initial}} + \boldsymbol{\tau}_{A, \mathrm{sys, net}} \Delta t
\(\angularmomentumprinciple\)
                                                                                //
\(\angularmomentumprincipleupdate \)
                                                                                //
                                                                                                    \Delta \overline{L}_{A, \mathrm{sys, net}}
\(\LHSangularmomentumprinciple*\)
\(\RHSangularmomentumprinciple*\)
                                                                                                     \overrightarrow{\tau}_{A, \mathrm{sys, net}} \Delta t
\(\LHSangularmomentumprincipleupdate*\)\\
                                                                                                    \overrightarrow{L}_{A, \rm sys, final}
\(\RHSangularmomentumprincipleupdate*\)\\
                                                                                                    \vec{L}_{A, \text{sys, final}}^{A, \text{sys, final}} + \vec{\tau}_{A, \text{sys, net}} \Delta t
\Delta \vec{L}_{A, \text{sys, net}} = \vec{\tau}_{A, \text{sys, net}} \Delta t
\vec{L}_{A, \text{sys, final}} = \vec{L}_{A, \text{sys, initial}} + \vec{\tau}_{A, \text{sys, net}} \Delta t
\( \angularmomentumprinciple* \)
\(\angularmomentumprincipleupdate* \)
```

5.4 Other Expressions

N 2021-02-13

$\ensuremath{\mbox{energyof}} \{\langle label \rangle\} [\langle label \rangle]$

Generic symbol for the energy of some entity.

<pre>\(\energyof{\symup{electron}} \) \\ \(\energyof{\symup{electron}}[\symup{final}] \)</pre>	$E_{ m electron} \ E_{ m electron,final}$
--	---

N 2021-02-13

\systemenergy $[\langle label \rangle]$

Symbol for system energy.

<pre>\(\systemenergy \) \\ \(\systemenergy[\symup{final}] \)</pre>	$E_{\rm sys} \\ E_{\rm sys,final}$
--	------------------------------------

N 2021-02-13

$\protect\$ \protect $\protect\$ \prot

Symbol for particle energy.

<pre>\(\particleenergy \) \\ \(\particleenergy[\symup{final}] \)</pre>	$E_{ m particle} \ E_{ m particle,final}$
--	---

N 2021-02-13

$\rule (label)$

Symbol for rest energy.

N 2021-02-13

$\time lenergy [\langle label \rangle]$

Symbol for internal energy.

<pre>\(\internalenergy \) \\ \(\internalenergy[\symup{final}] \)</pre>	$E_{ m internal} \ E_{ m internal, final}$
--	--

N 2021-02-13

\chemicalenergy $[\langle label \rangle]$

Symbol for chemical energy.

<pre>\(\chemicalenergy \) \\ \(\chemicalenergy[\symup{final}] \)</pre>	$E_{ m chem} \ E_{ m chem,final}$
--	-----------------------------------

N 2021-02-13

$\text{ \text{thermalenergy} [($label)$]}$

Symbol for thermal energy.

N 2021-02-13

\photonenergy [$\langle label \rangle$]

Symbol for photon energy.

<pre>\(\photonenergy \) \\ \(\photonenergy[\symup{final}] \)</pre>	$E_{ m photon} \ E_{ m photon,final}$
--	---------------------------------------

N 2021-02-13

N 2021-02-13

Symbol for translational kinetic energy. The starred variant gives ${\cal E}$ notation.

<pre>\(\translationalkineticenergy \) \\ \(\translationalkineticenergy[\symup{initial}] \) \\ \(\translationalkineticenergy* \) \\ \(\translationalkineticenergy*[\symup{initial}] \)</pre>	$K_{ m trans}$ $K_{ m trans,initial}$ $E_{ m K}$ $E_{ m K,initial}$
---	---

N 2021-02-13 N 2021-02-13

$\triangledown \triangledown \triangledown$

$\triangle \triangle \tri$

Symbol for rotational kinetic energy. The starred variant gives E notation.

<pre>\(\rotationalkineticenergy \) \\ \(\rotationalkineticenergy[\symup{initial}] \) \\ \(\rotationalkineticenergy* \) \\ \(\rotationalkineticenergy*[\symup{initial}] \)</pre>	$K_{ m rot} \ K_{ m rot,initial} \ E_{ m rot} \ E_{ m rot,initial}$
---	---

N 2021-02-13

N 2021-02-13

Symbol for vibrational kinetic energy. The starred variant gives E notation.

<pre>\(\vibrationalkineticenergy \) \\ \(\vibrationalkineticenergy[\symup{initial}] \) \\ \(\vibrationalkineticenergy* \) \\ \(\vibrationalkineticenergy*[\symup{initial}] \)</pre>	$K_{ m vib}$ $K_{ m vib,initial}$ $E_{ m vib}$ $E_{ m vib,initial}$
---	---

N 2021-02-13

$\gravitationalpotentialenergy[\langle label\rangle]$

Symbol for gravitational potential energy.

<pre>\(\gravitationalpotentialenergy \) \\ \(\gravitationalpotentialenergy[\symup{final}] \)</pre>	$U_{f g}$ $U_{f g, final}$	
--	----------------------------	--

N 2021-02-13

$\ensuremath{\mbox{\mbox{\mbox{\sim}}}\ensuremath{\mbox{\mbox{\sim}}}\ensuremath{\mbox{\sim}}\ensuremath{\mbox{\mbox{\sim}}}\ensuremath{\mbox{\mbox{\sim}}}\ensuremath{\mbox{\mbox{\sim}}}\ensuremath{\mbox{\sim}}\e$

Symbol for electric potential energy.

```
\( \electricpotentialenergy \) \\ \( \electricpotentialenergy[\symup{final}] \) U_{\rm e} = U_{\rm e,final}
```

N 2021-02-13

\springpotentialenergy [$\langle label \rangle$]

Symbol for spring potential energy.

```
\(\springpotentialenergy \) \\ \(\springpotentialenergy[\symup{final}] \) U_{\rm S} = U_{\rm S,final}
```

6 Source Code

31 \RequirePackage{nicematrix}

33 \RequirePackage{tensor}

36 \RequirePackage{hyperref}

34 \RequirePackage{tikz}

37 \RequireLuaTeX

32 \RequirePackage[most]{tcolorbox}

35 \usetikzlibrary{shapes,fit,tikzmark}

Definine the package version and date for global use, exploiting the fact that in a .sty file there is now no need for \makeatletter and \makeatother. This simplifies defining internal commands, with @ in the name, that are not for the user to know about.

```
1 \def\mandi@Version{3.0.0c}
2 \def\mandi@Date{2021-02-20}
3 \NeedsTeXFormat{LaTeX2e}[1999/12/01]
4 \providecommand\DeclareRelease[3]{}
5 \providecommand\DeclareCurrentRelease[2]{}
6 \DeclareRelease{v3.0.0c}{2021-02-20}{mandi.sty}
7 \DeclareCurrentRelease{v\mandi@Version}{\mandi@Date}
8 \ProvidesPackage{mandi}[\mandi@Date\space v\mandi@Version\space Macros for introductory physics]
   Define a convenient package version command.
9 \newcommand*{\mandiversion}{v\mandi@Version\space dated \mandi@Date}
   Set up the fonts to be consistent with ISO 80000-2 notation. The unicode-math package loads the fontspec and xparse
packages. Note that xparse is now part of the IATFX kernel. Because unicode-math is required, all documents using mandi
must be compiled with an engine that supports Unicode. We recommend LuaLATEX.
10 \RequirePackage{unicode-math}
11 \unimathsetup{math-style=ISO}
12 \unimathsetup{warnings-off={mathtools-colon,mathtools-overbracket}}
13 \setmathfont[Scale=MatchLowercase] {TeX Gyre DejaVu Math} % single-storey g everywhere. Based on Arev.
   Use normal math letters from Latin Modern Math for familiarity with textbooks.
14 \setmathfont[Scale=MatchLowercase,range=it/]{Latin Modern Math}
   Borrow mathscr and mathbfscr from XITS Math.
See https://tex.stackexchange.com/a/120073/218142.
15 \setmathfont[Scale=MatchLowercase, range={\mathscr, \mathbfscr}]{XITS Math}
   Get original and bold mathcal fonts.
See https://tex.stackexchange.com/a/21742/218142.
16 \setmathfont[Scale=MatchLowercase,range={\mathcal,\mathbfcal},StylisticSet=1]{XITS Math}
   Borrow Greek letters from Latin Modern Math.
17 \setmathfont[Scale=MatchLowercase,range=
                                               it/{greek,Greek}]{Latin Modern Math}
18 \setmathfont[Scale=MatchLowercase, range bfit/{greek,Greek}]{Latin Modern Math}
19 \setmathfont[Scale=MatchLowercase,range=
                                               up/{greek,Greek}]{Latin Modern Math}
20 \setmathfont[Scale=MatchLowercase,range= bfup/{greek,Greek}]{Latin Modern Math}
21 \setmathfont[Scale=MatchLowercase, range=bfsfup/{greek, Greek}] {Latin Modern Math}
   Load third party packages, documenting why each one is needed.
                                              % AMS goodness (don't load amssymb or amsfonts)
22 \RequirePackage{amsmath}
23 \RequirePackage[inline] {enumitem}
                                              % needed for physicsproblem environment
24 \RequirePackage{eso-pic}
                                              % needed for \hilite
25 \RequirePackage[g]{esvect}
                                              % needed for nice vector arrow, style g
26 \RequirePackage{pgfopts}
                                              % needed for key-value interface
27 \RequirePackage{array}
                                              % needed for \checkquantity and \checkconstant
28 \RequirePackage{iftex}
                                              % needed for requiring LuaLaTeX
29 \RequirePackage{makebox}
                                              % needed for consistent \dirvect; \makebox
30 \RequirePackage{mathtools}
                                              % needed for paired delimiters; extends amsmath
```

% needed for column and row vectors

% needed for program listings

% needed for index notation

% needed for \hilite

% needed for \hilite

% require this engine

% load last

Need to tweak the esvect package fonts to get the correct font size. Code provided by @egreg. See https://tex.stackexchange.com/a/566676.

```
38 \DeclareFontFamily{U}{esvect}{}
39 \DeclareFontShape{U}{esvect}{m}{n}{%
   <-5.5> vect5
    <5.5-6.5> vect6
41
   <6.5-7.5> vect7
42
   <7.5-8.5> vect8
43
    <8.5-9.5> vect9
44
    <9.5-> vect10
45
46 }{}%
47 \directlua{%
  luaotfload.add_colorscheme("colordigits",
     {["8000FF"] = {"one", "two", "three", "four", "five", "six", "seven", "eight", "nine", "zero"}})
49
50 }%
51 \newfontfamily\colordigits{DejaVuSansMono} [RawFeature={color=colordigits}]
```

Set up a color scheme and a new code environment for listings. The new colors are more restful on the eye. All listing commands now use tcolorbox.

See https://tex.stackexchange.com/a/529421/218142.

```
52 \newfontfamily{\gsfontfamily}{DejaVuSansMono}
                                                     % new font for listings
53 \definecolor{gsbggray}
                              {rgb}{0.90,0.90,0.90} % background gray
54 \definecolor{gsgray}
                              {rgb}{0.30,0.30,0.30} % gray
55 \definecolor{gsgreen}
                              {rgb}{0.00,0.60,0.00} % green
56 \definecolor{gsorange}
                              {rgb}{0.80,0.45,0.12} % orange
57 \definecolor{gspeach}
                              \{rgb\}\{1.00,0.90,0.71\} % peach
58 \definecolor{gspearl}
                              {rgb}{0.94,0.92,0.84} % pearl
59 \definecolor{gsplum}
                              \{rgb\}\{0.74,0.46,0.70\} % plum
60 \lstdefinestyle{vpython}{%
                                                     % style for listings
    backgroundcolor=\color{gsbggray},%
                                                     % background color
    basicstyle=\colordigits\footnotesize,%
                                                     % default style
62
                                                     % break at whitespace
63
    breakatwhitespace=true%
64
    breaklines=true,%
                                                     % break long lines
    captionpos=b,%
                                                     % position caption
65
                                                     % STILL DON'T UNDERSTAND THIS
    classoffset=1,%
66
    commentstyle=\color{gsgray},%
                                                     % font for comments
67
    deletekeywords={print},%
                                                     % delete keywords from the given language
68
    emph={self,cls,@classmethod,@property},%
                                                     % words to emphasize
69
    emphstyle=\color{gsorange}\itshape,%
70
                                                     % font for emphasis
    escapeinside={(*0}{0*)},%
                                                     % add LaTeX within your code
    frame=tb,%
                                                     % frame style
72
    framerule=2.0pt,%
                                                     % frame thickness
73
    framexleftmargin=5pt,%
                                                     % extra frame left margin
74
                                                      % style for identifiers
    %identifierstyle=\sffamily,%
75
    keywordstyle=\gsfontfamily\color{gsplum},%
                                                     % color for keywords
76
    language=Python,%
                                                     % select language
77
    linewidth=\linewidth,%
                                                     % width of listings
78
                                                     % VPython/GlowScript specific keywords
79
    morekeywords={%
      __future__,abs,acos,align,ambient,angle,append,append_to_caption,%
80
      append_to_title,arange,arrow,asin,astuple,atan,atan2,attach_arrow,%
81
      attach_trail,autoscale,axis,background,billboard,bind,black,blue,border,%
82
      bounding_box,box,bumpaxis,bumpmap,bumpmaps,camera,canvas,caption,capture,%
83
84
      ceil,center,clear,clear_trail,click,clone,CoffeeScript,coils,color,combin,%
      comp, compound, cone, convex, cos, cross, curve, cyan, cylinder, data, degrees, del, %
85
      delete,depth,descender,diff_angle,digits,division,dot,draw_complete,%
86
      ellipsoid, emissive, end_face_color, equals, explog, extrusion, faces, factorial, %
87
      False, floor, follow, font, format, forward, fov, frame, gcurve, gdisplay, gdots, %
88
      get_library,get_selected,ghbars,global,GlowScript,graph,graphs,green,gvbars,%
89
```

```
hat, headlength, headwidth, height, helix, hsv to rgb, index, interval, keydown, %
90
       kevup.label.length.lights.line.linecolor.linewidth.logx.logv.lower left.%
91
       lower_right, mag, mag2, magenta, make_trail, marker_color, markers, material, %
92
       max,min,mouse,mousedown,mousemove,mouseup,newball,norm,normal,objects,%
93
       offset, one, opacity, orange, origin, path, pause, pi, pixel_to_world, pixels, plot, %
94
       points, pos, pow, pps, print, print_function, print_options, proj, purple, pyramid, %
95
96
       quad, radians, radius, random, rate, ray, read_local_file, readonly, red, redraw, %
       retain, rgb to hsv, ring, rotate, round, scene, scroll, shaftwidth, shape, shapes, %
97
       shininess, show_end_face, show_start_face, sign, sin, size, size_units, sleep, %
98
       smooth, space, sphere, sqrt, start, start face_color, stop, tan, text, textpos, %
99
       texture, textures, thickness, title, trail_color, trail_object, trail_radius, %
100
       trail_type,triangle,trigger,True,twist,unbind,up,upper_left,upper_right,%
101
       userpan, userspin, userzoom, vec, vector, vertex, vertical_spacing, visible, %
102
       visual, vpython, VPython, waitfor, white, width, world, xtitle, yellow, yoffset, %
103
       ytitle%
104
     },%
105
106
     morekeywords={print, None, TypeError}, %
                                                       % additional keywords
     morestring=[b]{"""},%
                                                       % treat triple quotes as strings
107
     numbers=left,%
                                                       % where to put line numbers
     numbersep=10pt,%
                                                       % how far line numbers are from code
     numberstyle=\bfseries\tiny,%
                                                       % set to 'none' for no line numbers
110
     showstringspaces=false,%
                                                       % show spaces in strings
111
     showtabs=false,%
                                                       % show tabs within strings
112
     stringstyle=\gsfontfamily\color{gsgreen},%
                                                       % color for strings
113
                                                       % how to typeset quotes
     upquote=true,%
114
115 }%
    Introduce a new, more intelligent glowscriptblock P. 25 environment.
116 \NewTCBListing[auto counter,list inside=gsprogs]{glowscriptblock}{ O{} D(){glowscript.org} m }{%
     breakable.%
117
     center,%
118
     code = \newpage,%
119
    %derivpeach,%
     enhanced, %
121
     hyperurl interior = https://#2,%
122
     label = {gs:\thetcbcounter},%
123
     left = 8mm, %
124
     list entry = \texttt{GlowScript} Program \thetcbcounter: #3,%
125
126
     listing only,%
     listing style = vpython,%
127
     nameref = #3,%
128
     title = \texttt{GlowScript} Program \thetcbcounter: #3,%
130
    width = 0.9\textwidth,%
131
    #1.
132 }%
    A new command for generating a list of GlowScript programs.
133 \NewDocumentCommand{\listofglowscriptprograms}{}{\tcblistof[\section*]{gsprogs}
     {List of \texttt{GlowScript} Programs}}%
    Introduce a new, more intelligent \vpythonfile \cdot P. 28 command.
135 \NewTCBInputListing[auto counter,list inside=vpprogs]{\vpythonfile}{ 0{} m m }{%
136
    breakable,%
     center,%
137
138
     code = \newpage,%
139
     %derivgray,%
140
     enhanced, %
     hyperurl interior = https://,%
141
     label = {vp:\thetcbcounter},%
```

```
left = 8mm, %
143
     list entry = \texttt{VPython} Program \thetcbcounter: #3,%
144
     listing file = \{\#2\},%
145
     listing only,%
146
     listing style = vpython,%
147
     nameref = #3,%
148
     title = \texttt{VPython} Program \thetcbcounter: #3,%
     width = 0.9\textwidth,%
     #1,%
151
152 }%
    A new command for generating a list of VPython programs.
153 \NewDocumentCommand{\listofvpythonprograms}{}{\tcblistof[\section*]{vpprogs}
     {List of \texttt{VPython} Programs}}%
    Introduce a new \glowscriptinline \, P. 30 command.
155 \DeclareTotalTCBox{\glowscriptinline}{ m }{%
     bottom = Opt,%
     bottomrule = 0.0mm,%
     boxsep = 1.0mm,%
     colback = gsbggray,%
159
     colframe = gsbggray,%
160
     left = Opt,%
161
     leftrule = 0.0mm,%
162
     nobeforeafter,%
163
     right = Opt,%
164
     rightrule = 0.0mm,%
165
166
     sharp corners,%
     tcbox raise base,%
167
     top = Opt,%
168
     toprule = 0.0mm,%
169
170 }{\lstinline[style = vpython]{#1}}%
    Define \vpythoninline \frac{1}{2}P. 30, a semantic alias for VPython in-line listings.
```

171 \NewDocumentCommand{\vpythoninline}{}{\glowscriptinline}%

Define units to be used with the unit engine. All single letter macros are now gone. We basically absorbed and adapted the now outdated Slunits package. We make use of \symup{...} from the unicode-math package.

```
172 \NewDocumentCommand{\per}{}{\ensuremath{/}}
173 \NewDocumentCommand{\usk}{}{\ensuremath{\cdot}}
174 \NewDocumentCommand{\unit}{ m m }{\ensuremath{{#1}\;{#2}}}
175 \NewDocumentCommand{\ampere}{}{\ensuremath{\symup{A}}}}
176 \NewDocumentCommand{\atomicmassunit}{}{\ensuremath{\symup{u}}}}
177 \NewDocumentCommand{\candela}{}{\ensuremath{\symup{cd}}}}
178 \NewDocumentCommand{\coulomb}{}{\ensuremath{\symup{C}}}}
179 \NewDocumentCommand{\degree}{}{\ensuremath{^{\circ}}}
180 \NewDocumentCommand{\electronvolt}{}{\ensuremath{\symup{eV}}}}
181 \NewDocumentCommand{\farad}{}{\ensuremath{\symup{F}}}
182 \NewDocumentCommand{\henry}{}{\ensuremath{\symup{H}}}}
183 \NewDocumentCommand{\hertz}{}{\ensuremath{\symup{Hz}}}}
184 \NewDocumentCommand{\joule}{}{\ensuremath{\symup{J}}}}
185 \NewDocumentCommand{\kelvin}{}{\ensuremath{\symup{K}}}}
186 \NewDocumentCommand{\kilogram}{}{\ensuremath{\symup{kg}}}
187 \NewDocumentCommand{\lightspeed}{}{\ensuremath{\symup{c}}}
188 \MewDocumentCommand{\meter}{}{\nsuremath{\symup{m}}}
189 \NewDocumentCommand{\metre}{}{\meter}
190 \NewDocumentCommand{\mole}{}{\ensuremath{\symup{mol}}}
191 \NewDocumentCommand{\newton}{}{\ensuremath{\symup{N}}}}
192 \NewDocumentCommand{\ohm}{}{\ensuremath{\symup\Omega}}
```

```
193 \NewDocumentCommand{\pascal}{}{\ensuremath{\symup{Pa}}}
194 \NewDocumentCommand{\radian}{}{\ensuremath{\symup{rad}}}}
195 \NewDocumentCommand{\second}{}{\ensuremath{\symup{s}}}
196 \NewDocumentCommand{\siemens}{}{\ensuremath{\symup{S}}}}
197 \NewDocumentCommand{\steradian}{}{\ensuremath{\symup{sr}}}
198 \NewDocumentCommand{\tesla}{}\ensuremath{\symup{T}}}
199 \NewDocumentCommand{\volt}{}{\ensuremath{\symup{V}}}}
200 \NewDocumentCommand{\watt}{}{\ensuremath{\symup{W}}}}
201 \NewDocumentCommand{\weber}{}{\ensuremath{\symup{Wb}}}
202 \NewDocumentCommand{\square}{ m }{\ensuremath{{#1}^2}}
                                                                     % prefix
203 \NewDocumentCommand{\cubic}{ m }{\ensuremath{{#1}^3}}
                                                                     % prefix
204 \NewDocumentCommand{\quartic}{ m }{\ensuremath{{#1}^4}}
                                                                     % prefix
205 \NewDocumentCommand{\reciprocal}{ m }{\ensuremath{{#1}^{-1}}}
                                                                     % prefix
                                                                               -1
206 \NewDocumentCommand{\reciprocalsquare}{ m }{\censuremath{{#1}^{-2}}}
                                                                     % prefix
                                                                     % prefix
207 \NewDocumentCommand{\reciprocalcubic}{ m }{\ensuremath{{#1}^{-3}}}
208 \NewDocumentCommand{\reciprocalquartic}{ m }{\ensuremath{{#1}^{-4}}} % prefix -4
209 \NewDocumentCommand{\squared}{}{\ensuremath{^2}}
                                                                     % postfix 2
210 \NewDocumentCommand{\cubed}{}{\ensuremath{^3}}
                                                                     % postfix 3
% postfix 4
212 \NewDocumentCommand{\reciprocaled}{}{\ensuremath{^{-1}}}
                                                                     % postfix -1
213 \ensuremath{^{-2}}
                                                                     % postfix -2
214 \ensuremath{^{-3}}
                                                                     % postfix -3
215 \MewDocumentCommand{\reciprocalquarted}{}{\newDocumenth{^{-}\{-4\}}}
                                                                     % postfix -4
216 \NewDocumentCommand{\emptyunit}{}{\ensuremath{\mdlgwhtsquare}}
    The core unit engine has been completely rewritten in expl3 for both clarity and power.
    Generic internal selectors.
217 \newcommand*{\mandi@selectunits}{}
218 \newcommand*{\mandi@selectprecision}{}
    Specific internal selectors.
219 \newcommand*{\mandi@selectapproximate}[2]{#1}
                                                  % really \@firstoftwo
220 \newcommand*{\mandi@selectprecise}[2]{#2}
                                                  % really \@secondoftwo
221 \newcommand*{\mandi@selectbaseunits}[3]{#1}
                                                  % really \Offirstofthree
222 \newcommand*{\mandi@selectderivedunits}[3]{#2}
                                                  % really \@secondofthree
223 \newcommand*{\mandi@selectalternateunits}[3]{#3} % really \@thirdofthree
    Document level global switches.
224 \NewDocumentCommand{\alwaysusebaseunits}{}
     {\renewcommand*{\mandi@selectunits}{\mandi@selectbaseunits}}%
226 \NewDocumentCommand{\alwaysusederivedunits}{}
     {\renewcommand*{\mandi@selectunits}{\mandi@selectderivedunits}}%
228 \NewDocumentCommand{\alwaysusealternateunits}{}
     {\renewcommand*{\mandi@selectunits}{\mandi@selectalternateunits}}%
230 \NewDocumentCommand{\alwaysuseapproximateconstants}{}
     {\renewcommand*{\mandi@selectprecision}{\mandi@selectapproximate}}%
232 \NewDocumentCommand{\alwaysusepreciseconstants}{}
    {\renewcommand*{\mandi@selectprecision}{\mandi@selectprecise}}%
233
    Document level localized variants.
235 \NewDocumentCommand{\hereusederivedunits}{ m }{\begingroup\alwaysusederivedunits#1\endgroup}%
236 \NewDocumentCommand{\hereusealternateunits}{ m }{\begingroup\alwaysusealternateunits#1\endgroup}%
237 \NewDocumentCommand{\hereuseapproximateconstants}{ m }{\begingroup\alwaysuseapproximateconstants#1\endgroup}%
238 \NewDocumentCommand{\hereusepreciseconstants}{ m }{\begingroup\alwaysusepreciseconstants#1\endgroup}%
    Document level environments.
239 \NewDocumentEnvironment{usebaseunits}{}{\alwaysusebaseunits}{}%
240 \NewDocumentEnvironment{usederivedunits}{}{\alwaysusederivedunits}{}%
```

```
241 \NewDocumentEnvironment{usealternateunits}{}{\alwaysusealternateunits}{}}
243 \NewDocumentEnvironment{usepreciseconstants}{}{\alwaysusepreciseconstants}{}}
    Defining a new scalar quantity:
244 \NewDocumentCommand{\newscalarquantity}{ m m 0{#2} 0{#2} }{%
     \expandafter\newcommand\csname #1\endcsname[1]{##1\,\mandi@selectunits{#2}{#3}{#4}}%
245
     \expandafter\newcommand\csname #1value\endcsname[1]{##1}%
246
     \expandafter\newcommand\csname #1baseunits\endcsname[1]{##1\,\mandi@selectbaseunits{#2}{#3}{#4}}%
247
     \expandafter\newcommand\csname #1derivedunits\endcsname[1]{##1\,\mandi@selectderivedunits{#2}{#3}{#4}}%
248
     \expandafter\newcommand\csname #1alternateunits\endcsname[1]{##1\,\mandi@selectalternateunits{#2}{#3}{#4}}%
249
     \expandafter\newcommand\csname #1onlybaseunits\endcsname{\mandi@selectbaseunits{#2}{#3}{#4}}%
250
     \expandafter\newcommand\csname #1onlyderivedunits\endcsname{\mandi@selectderivedunits{#2}{#3}{#4}}%
251
     \expandafter\newcommand\csname #1onlyalternateunits\endcsname{\mandi@selectalternateunits{#2}{#3}{#4}}%
252
253 }%
    Defining a new vector quantity. Note that a corresponding scalar is also defined.
254 \NewDocumentCommand{\newvectorquantity}{ m m 0{#2} 0{#2} }{%
     \newscalarquantity{#1}{#2}[#3][#4]
     \expandafter\newcommand\csname vector#1\endcsname[1]{\expandafter\csname #1\endcsname{\mivector{##1}}}%
256
257 }%
    Defining a new physical constant:
258 \NewDocumentCommand{\newphysicalconstant}{ m m m m 0{#5} 0{#5} }{%
259
     \expandafter\newcommand\csname #1\endcsname
       {\mandi@selectprecision{#3}{#4}\,\mandi@selectunits{#5}{#6}{#7}}%
260
     \expandafter\newcommand\csname #1mathsymbol\endcsname{\ensuremath{#2}}%
261
     \expandafter\newcommand\csname #1approximatevalue\endcsname{\ensuremath{#3}}%
262
     \expandafter\newcommand\csname #1precisevalue\endcsname{\ensuremath{#4}}%
263
     \expandafter\newcommand\csname #1baseunits\endcsname
264
       {\mandi@selectprecision{#3}{#4}\,\mandi@selectbaseunits{#5}{#6}{#7}}%
265
     \expandafter\newcommand\csname #1derivedunits\endcsname
266
       {\modelectprecision{#3}{#4}\,\modelectderivedunits{#5}{#6}{#7}}%
267
     \expandafter\newcommand\csname #1alternateunits\endcsname
268
       {\mandi@selectprecision{#3}{#4}\,\mandi@selectalternateunits{#5}{#6}{#7}}%
269
     \expandafter\newcommand\csname #1onlybaseunits\endcsname
270
       {\mandi@selectbaseunits{#5}{#6}{#7}}%
271
272
     \expandafter\newcommand\csname #1onlyderivedunits\endcsname
       {\mandi@selectderivedunits{#5}{#6}{#7}}%
273
274
     \expandafter\newcommand\csname #1onlyalternateunits\endcsname
275
       {\mandi@selectalternateunits{#5}{#6}{#7}}%
276 }%
    mandi now has a key-value interface, implemented with pgfopts and pgfkeys. There are two options:
units P.6, with values base, derived, or alternate selects the default form of units
preciseconstants ^{\rightarrow P.6}, with values true and false, selects precise numerical values for constants rather than approximate
values.
    First, define the keys. The key handlers require certain commands defined by the unit engine, and thus must be defined
and processed after the unit engine code.
277 \newif\ifusingpreciseconstants
278 \pgfkeys{%
     /mandi/options/.cd,
279
     initial@setup/.style={%
280
281
       /mandi/options/buffered@units/.initial=alternate,%
282
     },%
     initial@setup,%
283
     preciseconstants/.is if=usingpreciseconstants,%
284
     units/.is choice,%
285
```

units/.default=derived,%

286

Process the options.

291 \ProcessPgfPackageOptions{/mandi/options}

Write a banner to the console showing the options in use. The value of the units P.6 key is used in situ to set the default units.

```
292 \newcommand*{\mandi@linetwo}{\typeout{mandi: Loadtime options...}}
293 \newcommand*{\mandi@do@setup}{%
     \typeout{}%
     \typeout{mandi: You are using mandi \mandiversion.}%
295
     \mandi@linetwo
296
     \csname alwaysuse\pgfkeysvalueof{/mandi/options/buffered@units}units\endcsname%
297
     \typeout{mandi: You will get \pgfkeysvalueof{/mandi/options/buffered@units}\space units.}%
298
     \ifusingpreciseconstants
299
       \alwaysusepreciseconstants
300
301
       \typeout{mandi: You will get precise constants.}%
302
     \else
       \alwaysuseapproximateconstants
303
       \typeout{mandi: You will get approximate constants.}%
304
     \fi
305
     \typeout{}%
306
307 }%
308 \mandi@do@setup
```

Define a setup command that overrides the loadtime options when called with new options. A new banner is written to the console.

```
309 \NewDocumentCommand{\mandisetup}{ m }{%
310 \IfValueT{#1}{%
311 \pgfqkeys{/mandi/options}{#1}
312 \renewcommand*{\mandi@linetwo}{\typeout{mandi: mandisetup options...}}
313 \mandi@do@setup
314 }%
315 }%
```

Define every quantity we need in introductory physics, alphabetically for convenience. This is really the core feature of mandi that no other package offers. There are commands for quantities that have no dimensions or units, and these quantities are defined for semantic completeness.

```
316 \newvectorquantity{acceleration}%
     {\meter\usk\second\reciprocalsquared}%
     [\newton\per\kilogram]%
318
     [\meter\per\second\squared]%
319
320 \newscalarquantity{amount}%
     {\mole}%
321
322 \newvectorquantity{angularacceleration}%
     {\radian\usk\second\reciprocalsquared}%
323
     [\radian\per\second\squared]%
324
     [\radian\per\second\squared]%
326 \newscalarquantity{angularfrequency}%
     {\radian\usk\reciprocal\second}%
     [\radian\per\second]%
     [\radian\per\second]%
330 %\ifmandi@rotradians
331 % \newphysicalquantity{angularimpulse}%
        {\meter\squared\usk\kilogram\usk\reciprocal\second\usk\reciprocal\radian}%
332 %
        [\joule\usk\second\per\radian]%
333 %
```

```
[\newton\usk\meter\usk\second\per\radian]%
334 %
335 %
      \newphysicalquantity{angularmomentum}%
336 %
        {\meter\squared\usk\kilogram\usk\reciprocal\second\usk\reciprocal\radian}%
337 %
        [\kilogram\usk\meter\squared\per(\second\usk\radian)]%
338 %
        [\newton\usk\meter\usk\second\per\radian]%
339 %\else
340
     \newvectorquantity{angularimpulse}%
       {\meter\squared\usk\kilogram\usk\reciprocal\second}%
341
       [\kilogram\usk\meter\squared\per\second] % % also \joule\usk\second
342
       [\kilogram\usk\meter\squared\per\second]% % also \newton\usk\meter\usk\second
343
     \newvectorquantity{angularmomentum}%
344
       {\meter\squared\usk\kilogram\usk\reciprocal\second}%
345
       [\kilogram\usk\meter\squared\per\second]% % also \joule\usk\second
346
       [\kilogram\usk\meter\squared\per\second]% % also \newton\usk\meter\usk\second
347
348 %\fi
349 \newvectorquantity{angularvelocity}%
     {\radian\usk\reciprocal\second}%
350
     [\radian\per\second]%
351
     [\radian\per\second]%
353 \newscalarquantity{area}%
     {\meter\squared}%
355 \newscalarquantity{areamassdensity}%
     {\meter\reciprocalsquared\usk\kilogram}%
356
     [\kilogram\per\meter\squared]%
357
     [\kilogram\per\meter\squared]%
358
359 \newscalarquantity{areachargedensity}%
     {\reciprocalsquare\meter\usk\second\usk\ampere}%
     [\coulomb\per\square\meter]%
361
     [\coulomb\per\square\meter]%
362
363 \newscalarquantity{capacitance}%
     {\reciprocalsquare\meter\usk\reciprocal\kilogram\usk\quartic\second\usk\square\ampere}%
364
365
     [\coulomb\per\volt]% % also \coulomb\squared\per\newton\usk\meter, \second\per\ohm
367 \newscalarquantity{charge}%
     {\ampere\usk\second}%
     [\coulomb]%
369
     [\coulomb]% % also \farad\usk\volt
370
371 \newvectorquantity{cmagneticfield}%
     {\meter\usk\kilogram\usk\second\reciprocalcubed\usk\reciprocal\ampere}%
     [\volt\per\meter]%
373
     [\newton\per\coulomb]%
374
375 \newscalarquantity{conductance}%
376
     {\reciprocalsquare\meter\usk\reciprocal\kilogram\usk\cubic\second\usk\square\ampere}}
     [\siemens]%
377
     [\ampere\per\volt]%
378
379 \newscalarquantity{conductivity}%
     {\reciprocalcubic\meter\usk\reciprocal\kilogram\usk\cubic\second\usk\square\ampere}}
381
     [\siemens\per\meter]%
     [(\ampere\per\square\meter)\per(\volt\per\meter)]%
382
383 \newscalarquantity{conventionalcurrent}%
     {\ampere}%
384
     [\coulomb\per\second]%
385
     [\ampere]%
387 \newscalarquantity{current}%
     {\ampere}%
388
389 \newscalarquantity{currentdensity}%
390
     {\reciprocalsquare\meter\usk\ampere}%
391
     [\coulomb\usk\second\per\square\meter]%
392
     [\ampere\per\square\meter]%
```

```
393 \newscalarguantity{dielectricconstant}%
     {}%
394
395 \newvectorquantity{displacement}%
     {\meter}
396
397 \newscalarquantity{duration}%
     {\second}%
399 \newvectorquantity{electricdipolemoment}%
     {\meter\usk\second\usk\ampere}%
     [\coulomb\usk\meter]%
401
     [\coulomb\usk\meter]%
402
403 \newvectorquantity{electricfield}%
     {\meter\usk\kilogram\usk\second\reciprocalcubed\usk\reciprocal\ampere}%
     [\volt\per\meter]%
405
     [\newton\per\coulomb]%
407 \newscalarquantity{electricflux}%
     {\meter\cubed\usk\kilogram\usk\second\reciprocalcubed\usk\reciprocal\ampere}%
408
     [\volt\usk\meter]%
409
     [\newton\usk\meter\squared\per\coulomb]%
410
411 \newscalarquantity{electricpotential}%
     {\square\meter\usk\kilogram\usk\reciprocalcubic\second\usk\reciprocal\ampere}%
413
     [\volt]%
     [\joule\per\coulomb]%
414
415 \newscalarquantity{electroncurrent}%
     {\reciprocal\second}%
416
     [\ensuremath{\symup{e}}\per\second]%
417
     [\ensuremath{\symup{e}}\per\second]%
418
419 \newscalarquantity{emf}%
     {\square\meter\usk\kilogram\usk\reciprocalcubic\second\usk\reciprocal\ampere}%
420
     [\volt]%
421
     [\joule\per\coulomb]%
422
423 \newscalarquantity{energy}%
     {\meter\squared\usk\kilogram\usk\second\reciprocalsquared}%
424
425
     [\joule]% % also \newton\usk\meter
426
     [\joule]%
427 \newscalarquantity{energydensity}%
     {\meter\reciprocaled\usk\kilogram\usk\reciprocalsquare\second}%
428
     [\joule\per\cubic\meter]%
429
     [\joule\per\cubic\meter]%
430
431 \newscalarquantity{energyflux}%
     {\kilogram\usk\second\reciprocalcubed}%
433
     [\watt\per\meter\squared]%
     [\watt\per\meter\squared]%
434
435 \newscalarquantity{entropy}%
     {\meter\squared\usk\kilogram\usk\second\reciprocalsquared\usk\reciprocal\kelvin}%
436
437
     [\joule\per\kelvin]%
     [\joule\per\kelvin]%
439 \newvectorquantity{force}%
     {\meter\usk\kilogram\usk\second\reciprocalsquared}%
440
441
     [\newton]% % also \kilogram\usk\meter\per\second\squared
442
443 \newscalarquantity{frequency}%
     {\reciprocal\second}%
444
     [\hertz]%
445
     [\hertz]%
446
447 \newvectorquantity{gravitationalfield}%
     {\meter\usk\second\reciprocalsquared}%
448
     [\newton\per\kilogram]%
449
450
     [\newton\per\kilogram]%
451 \newscalarquantity{gravitationalpotential}%
```

```
{\square\meter\usk\reciprocalsquare\second}%
452
     [\joule\per\kilogram]%
453
     [\joule\per\kilogram]%
454
455 \newvectorquantity{impulse}%
     {\meter\usk\kilogram\usk\reciprocal\second}%
456
     [\newton\usk\second]%
457
458
     [\newton\usk\second]%
459 \newscalarquantity{indexofrefraction}%
460
461 \newscalarquantity{inductance}%
     {\square\meter\usk\kilogram\usk\reciprocalsquare\second\usk\reciprocalsquare\ampere}}
462
     [\henry]%
463
     [\volt\usk\second\per\ampere]% % also \square\meter\usk\kilogram\per\coulomb\squared, \Wb\per\ampere
465 \newscalarquantity{linearchargedensity}%
     {\reciprocal\meter\usk\second\usk\ampere}%
466
     [\coulomb\per\meter]%
467
     [\coulomb\per\meter]%
468
469 \newscalarquantity{linearmassdensity}%
     {\reciprocal\meter\usk\kilogram}%
     [\kilogram\per\meter]%
     [\kilogram\per\meter]%
472
473 \newscalarquantity{luminous}%
     {\candela}%
474
475 \newscalarquantity{magneticcharge}%
     {\meter\usk\ampere}%
477 \newvectorquantity{magneticdipolemoment}%
     {\square\meter\usk\ampere}%
     [\ampere\usk\square\meter]%
479
     [\joule\per\tesla]%
480
481 \newvectorquantity{magneticfield}%
     {\kilogram\usk\second\reciprocalsquared\usk\reciprocal\ampere}%
482
     [\tesla]%
483
     [\newton\per\coulomb\usk(\meter\per\second)]% % also \Wb\per\meter\squared
485 \newscalarquantity{magneticflux}%
     {\meter\squared\usk\kilogram\usk\second\reciprocalsquared\usk\reciprocal\ampere}%
486
     [\tesla\usk\meter\squared]%
487
     [\volt\usk\second]% % also \Wb and \joule\per\ampere
488
489 \newscalarquantity{mass}%
     {\kilogram}%
491 \newscalarquantity{mobility}%
     {\meter\squared\usk\kilogram\usk\second\reciprocalquarted\usk\reciprocal\ampere}%
492
     [\meter\squared\per\volt\usk\second]%
493
     [(\meter\per\second)\per(\newton\per\coulomb)]%
494
495 \newscalarquantity{momentofinertia}%
     {\meter\squared\usk\kilogram}%
496
497
     [\joule\usk\second\squared]%
     [\kilogram\usk\meter\squared]%
498
499 \newvectorquantity{momentum}%
     {\meter\usk\kilogram\usk\reciprocal\second}%
500
     [\newton\usk\second]%
501
     [\kilogram\usk\meter\per\second]%
502
503 \newvectorquantity{momentumflux}%
     {\reciprocal\meter\usk\kilogram\usk\second\reciprocalsquared}%
504
     [\newton\per\meter\squared]%
505
     [\newton\per\meter\squared]%
506
507 \newscalar
quantity
{numberdensity}%
     {\reciprocalcubic\meter}%
508
509
     [\per\cubic\meter]%
```

[\per\cubic\meter]%

```
511 \newscalarquantity{permeability}%
     {\meter\usk\kilogram\usk\second\reciprocalsquared\usk\ampere\reciprocalsquared}%
512
     [\tesla\usk\meter\per\ampere]%
513
     [\henry\per\meter]%
514
515 \newscalarquantity{permittivity}%
     {\meter\reciprocalcubed\usk\reciprocal\kilogram\usk\second\reciprocalquarted\usk\ampere\squared}%
517
     [\farad\per\meter]%
     [\coulomb\squared\per\newton\usk\meter\squared]%
518
519 \newscalarquantity{planeangle}%
     {\meter\usk\reciprocal\meter}%
     [\radian]%
521
     [\radian]%
522
523 \newscalarquantity{polarizability}%
     {\reciprocal\kilogram\usk\second\quarted\usk\square\ampere}%
     [\coulomb\usk\square\meter\per\volt]%
525
     [\coulomb\usk\meter\per(\newton\per\coulomb)]%
526
527 \newscalarquantity{power}%
     {\meter\squared\usk\kilogram\usk\second\reciprocalcubed}%
     [\watt]%
530
     [\joule\per\second]%
531 \newvectorquantity{poynting}%
     {\kilogram\usk\second\reciprocalcubed}%
     [\watt\per\meter\squared]%
533
     [\watt\per\meter\squared]%
534
535 \newscalarquantity{pressure}%
     {\reciprocal\meter\usk\kilogram\usk\second\reciprocalsquared}%
     [\pascal]%
537
     [\newton\per\meter\squared]%
538
539 \newscalarquantity{relativepermeability}
540
541 \newscalar
quantity{relative
permittivity}%
543 \newscalarquantity{resistance}%
     {\square\meter\usk\kilogram\usk\reciprocalcubic\second\usk\reciprocalsquare\ampere}%
544
     [\volt\per\ampere]%
545
     [\ohm]%
547 \newscalarquantity{resistivity}%
548
     {\cubic\meter\usk\kilogram\usk\reciprocalcubic\second\usk\reciprocalsquare\ampere}%
     [\ohm\usk\meter]%
     [(\volt\per\meter)\per(\ampere\per\square\meter)]%
551 \newscalarquantity{solidangle}%
     {\meter\squared\usk\reciprocalsquare\meter}%
552
553
     [\steradian]%
     [\steradian]%
555 \newscalarquantity{specificheatcapacity}%
556
     {\meter\squared\usk\second\reciprocalsquared\usk\reciprocal\kelvin}%
     [\joule\per\kelvin\usk\kilogram]%
557
     [\joule\per\kelvin\usk\kilogram]
558
559 \newscalarquantity{springstiffness}%
     {\kilogram\usk\second\reciprocalsquared}%
560
     [\newton\per\meter]%
561
     [\newton\per\meter]%
562
563 \newscalarquantity{springstretch}% % This is really just a displacement.
564
565 \newscalarquantity{stress}%
     {\reciprocal\meter\usk\kilogram\usk\second\reciprocalsquared}%
566
     [\pascal]%
567
568
     [\newton\per\meter\squared]%
569 \newscalarquantity{strain}%
```

```
570
     {}%
571 \newscalarquantity{temperature}%
    {\kelvin}%
573 %\ifmandi@rotradians
574 % \newphysicalquantity{torque}%
575 %
        {\meter\squared\usk\reciprocal\radian}%
576 %
        [\newton\usk\meter\per\radian]%
        [\newton\usk\meter\per\radian]%
577 %
578 %\else
     \newvectorquantity{torque}%
579
       {\meter\squared\usk\kilogram\usk\second\reciprocalsquared}%
580
       [\newton\usk\meter]%
581
       [\newton\usk\meter]%
582
583 %\fi
584 \newvectorquantity{velocity}%
     {\meter\usk\reciprocal\second}%
     [\meter\usk\reciprocal\second]%
586
     [\meter\per\second]%
587
588 \newvectorquantity{velocityc}%
     {\lightspeed}%
590
     [] %
     [\lightspeed]%
591
592 \newscalarquantity{volume}%
     {\cubic\meter}%
594 \newscalarquantity{volumechargedensity}%
     {\reciprocalcubic\meter\usk\second\usk\ampere}%
595
     [\coulomb\per\cubic\meter]%
596
     [\coulomb\per\cubic\meter]%
597
598 \newscalarquantity{volumemassdensity}%
     {\meter\reciprocalcubed\usk\kilogram}%
599
     [\kilogram\per\meter\cubed]%
600
     [\kilogram\per\meter\cubed]%
602 \newscalarquantity{wavelength}% % This is really just a displacement.
    {\meter}%
604 \newvectorquantity{wavenumber}%
     {\reciprocal\meter}%
605
     [\per\meter]%
606
     [\per\meter]%
608 \newscalarquantity{work}%
     {\meter\squared\usk\kilogram\usk\second\reciprocalsquared}%
609
610
     [\joule]%
     [\newton\usk\meter]%
612 \newscalar
quantity{youngsmodulus} \% % This is really just a stress.
     {\reciprocal\meter\usk\kilogram\usk\second\reciprocalsquared}%
613
614
     [\pascal]%
     [\newton\per\meter\squared]%
615
    Define physical constants for introductory physics, again alphabetically for convenience.
616 \newphysicalconstant{avogadro}%
    {N_A}
617
     \{6 \in \{23\}\} \{6.022140857 \in \{23\}\} \%
618
     {\reciprocal\mole}%
620 \newphysicalconstant{biotsavartconstant}% % alias for \mzofp
     {\frac{\mu_o}{4\pi^0}}
621
622
     {\tento{-7}}{\tento{-7}}%
623
     {\meter\usk\kilogram\usk\second\reciprocalsquared\\uk\ampere\reciprocalsquared\\%
624
     [\henry\per\meter]%
625
     [\tesla\usk\meter\per\ampere]%
626 \newphysicalconstant{bohrradius}%
```

```
{a 0}%
627
     \{5.3\timestento\{-11\}\}\{5.2917721067\timestento\{-11\}\}\%
628
     {\meter}%
629
630 \newphysicalconstant{boltzmann}%
    {k B}%
631
    {1.4\timestento{-23}}{1.38064852\timestento{-23}}%
632
    {\meter\squared\usk\kilogram\usk\reciprocalsquare\second\usk\reciprocal\kelvin}%
    [\joule\per\kelvin]%
634
     [\joule\per\kelvin]%
635
636 \newphysicalconstant{coulombconstant}% % alias for \oofpez
     {\frac{1}{4\pi\epsilon_o}}%
637
     {9\timestento{9}}{8.9875517873681764\timestento{9}}%
638
     {\meter\cubed\usk\kilogram\usk\reciprocalquartic\second\usk\ampere\reciprocalsquared}%
639
     [\meter\per\farad]%
     [\newton\usk\meter\squared\per\coulomb\squared]%
642 \newphysicalconstant{earthmass}%
    {M_{\symup{Earth}}}%
643
    \{6.0\timestento\{24\}\}\{5.97237\timestento\{24\}\}\%
644
    {\kilogram}%
646 \newphysicalconstant{earthmoondistance}%
    {d_{\symup{EM}}}%
    {3.8\timestento{8}}{3.81550\timestento{8}}%
    {\meter}%
650 \newphysicalconstant{earthradius}%
     {R_{\symup{Earth}}}%
     \{6.4 \times \{6.371 \times \{6.371 \times \{6.4\}\}\} \}
652
     {\meter}%
654 \newphysicalconstant{earthsundistance}%
     \{d_{\sim}\{symup\{ES\}\}\}%
     {1.5\timestento{11}}{1.496\timestento{11}}%
656
     {\meter}%
657
658 \newphysicalconstant{electroncharge}%
    {q_e}%
    {-\elementarychargeapproximatevalue}{-\elementarychargeprecisevalue}%
    {\ampere\usk\second}%
661
    [\coulomb]%
662
     [\coulomb]%
663
664 \newphysicalconstant{electronCharge}%
    {Q_e}%
     {-\elementarychargeapproximatevalue}{-\elementarychargeprecisevalue}%
666
     {\ampere\usk\second}%
667
668
     [\coulomb]%
669
     [\coulomb]%
670 \newphysicalconstant{electronmass}%
    {m_e}%
671
672 \{9.1 \times \{-31\}\} \{9.10938356 \times \{-31\}\} \%
673 {\kilogram}%
674 \newphysicalconstant{elementarycharge}%
675
    {1.6\times -19}{1.6021766208\times -19}%
676
     {\ampere\usk\second}%
677
     [\coulomb]%
678
     [\coulomb]%
680 \newphysicalconstant{finestructure}%
681
     {\alpha}%
682
     {\frac{1}{137}}{7.2973525664\times{-3}}%
683
684 \newphysicalconstant{hydrogenmass}%
```

 ${m_H}%$

```
\{1.7\timestento\{-27\}\}\{1.6737236\timestento\{-27\}\}\%
686
     {\kilogram}%
687
688 \newphysicalconstant{moonearthdistance}%
     {d_{\symup{ME}}}%
     {3.8\times 1550\times 8}
690
    {\meter}%
691
692 \newphysicalconstant{moonmass}%
    {M {\symup{Moon}}}%
    {7.3\timestento{22}}{7.342\timestento{22}}\%
694
    {\kilogram}%
695
696 \newphysicalconstant{moonradius}%
    {R_{\symup{Moon}}}%
     \{1.7\timestento\{6\}\}\{1.7371\timestento\{6\}\}\%
     {\meter}%
700 \newphysicalconstant{neutronmass}%
    {m_n}
701
702
    \{1.7\timestento\{-27\}\}\{1.674927471\timestento\{-27\}\}\%
    {\kilogram}%
703
704 \newphysicalconstant{oofpez}%
    {\frac{1}{4\pi\epsilon_o}}%
     {9}\times{9}\times{9}
     {\meter\cubed\usk\kilogram\usk\reciprocalquartic\second\usk\ampere\reciprocalsquared}%
707
     [\meter\per\farad]%
708
     [\newton\usk\meter\squared\per\coulomb\squared]%
709
710 \newphysicalconstant{oofpezcs}%
     {\frac{1}{4\pi c_1}}{4\pi c_0 c^2}}
     {\left(-7\right)}{\left(-7\right)}
712
     {\meter\usk\kilogram\usk\second\reciprocalsquared\usk\ampere\reciprocalsquared}%
713
     [\tesla\usk\meter\squared]%
714
     [\newton\usk\second\squared\per\coulomb\squared]%
715
716 \newphysicalconstant{planck}%
717
    {h}%
     \{6.6\timestento\{-34\}\}\{6.626070040\timestento\{-34\}\}\%
718
     {\meter\squared\usk\kilogram\usk\reciprocal\second}%
719
     [\joule\usk\second]%
720
     [\joule\usk\second]%
722 \newphysicalconstant{planckbar}%
   {\hslash}%
723
     {1.1\times -34}}{1.054571800\times -34}}%
724
     {\meter\squared\usk\kilogram\usk\reciprocal\second}%
725
     [\joule\usk\second]%
726
     [\joule\usk\second]
727
728 \newphysicalconstant{planckc}%
     {hc}%
729
     {2.0\times {-25}}{1.98644568\times {-25}}%
730
     {\meter\cubed\usk\kilogram\usk\reciprocalsquare\second}%
     [\joule\usk\meter]%
     [\joule\usk\meter]%
734 \newphysicalconstant{protoncharge}%
735
     {q_p}%
     {+\elementarychargeapproximatevalue}{+\elementarychargeprecisevalue}%
736
     {\ampere\usk\second}%
737
     [\coulomb]%
738
     [\coulomb]%
739
740 \newphysicalconstant{protonCharge}%
741
742
     {+\elementarychargeapproximatevalue}{+\elementarychargeprecisevalue}%
    {\ampere\usk\second}%
743
    [\coulomb]%
744
```

```
[\coulomb]%
745
746 \newphysicalconstant{protonmass}%
     {m_p}%
747
     \{1.7\timestento\{-27\}\}\{1.672621898\timestento\{-27\}\}\%
748
    {\kilogram}%
749
750 \newphysicalconstant{rydberg}%
     {R_{\left( \right)}}
     {1.1\timestento{7}}{1.0973731568508\timestento{7}}%
752
    {\reciprocal\meter}%
754 \newphysicalconstant{speedoflight}%
    {c}%
755
     {3\timestento{8}}{2.99792458\timestento{8}}%
756
     {\meter\usk\reciprocal\second}%
757
     [\meter\per\second]%
758
     [\meter\per\second]
759
760 \newphysicalconstant{stefanboltzmann}%
     {\sigma}%
761
     \{5.7\timestento\{-8\}\}\{5.670367\timestento\{-8\}\}\%
762
     {\kilogram\usk\second\reciprocalcubed\usk\kelvin\reciprocalquarted}%
764
     [\watt\per\meter\squared\usk\kelvin\quarted]%
     [\watt\per\meter\squared\usk\kelvin\quarted]
765
766 \newphysicalconstant{sunearthdistance}%
     {d_{\symup{SE}}}%
767
     \{1.5\timestento\{11\}\}\{1.496\timestento\{11\}\}\%
768
769
     {\meter}%
770 \newphysicalconstant{sunmass}%
     {M_{\scriptstyle symup}}
     \{2.0\timestento\{30\}\}\{1.98855\timestento\{30\}\}\%
772
     {\kilogram}%
773
774 \newphysicalconstant{sunradius}%
     {R_{\scriptstyle symup{Sun}}}
776
     {7.0\times \{6.957\times \{8\}\}}
     {\meter}%
778 \newphysicalconstant{surfacegravfield}%
     {g}%
779
     {9.8}{9.807}%
780
     {\meter\usk\second\reciprocalsquared}%
781
     [\newton\per\kilogram]%
782
     [\newton\per\kilogram]%
784 \newphysicalconstant{universalgrav}%
785
     \{6.7\timestento\{-11\}\}\{6.67408\timestento\{-11\}\}\%
786
     {\meter\cubed\usk\reciprocal\kilogram\usk\second\reciprocalsquared}%
787
     [\newton\usk\meter\squared\per\kilogram\squared]% % also \joule\usk\meter\per\kilogram\squared
788
     [\newton\usk\meter\squared\per\kilogram\squared]%
790 \newphysicalconstant{vacuumpermeability}%
791
     {4\pi}{4\pi}{timestento}{-7}}{4\pi}{timestento}{-7}}%
792
     {\meter\usk\kilogram\usk\second\reciprocalsquared\usk\ampere\reciprocalsquared}%
793
     [\henry\per\meter]%
794
     [\tesla\usk\meter\per\ampere]%
795
796 \newphysicalconstant{vacuumpermittivity}%
     {\epsilon_o}%
797
     {9 \times {-12}}{8.854187817 \times {-12}}%
798
     {\meter\reciprocalcubed\usk\reciprocal\kilogram\usk\second\quarted\usk\ampere\squared}%
799
     [\farad\per\meter]%
800
     [\coulomb\squared\per\newton\usk\meter\squared]%
801
```

A better, intelligent coordinate-free \vec^\rightarrow P.30 command. Note the use of the e{_^} type of optional argument. This

accounts for much of the flexibility and power of this command. Also note the use of the TEX primitives \sb{} and \sp{}. Why doesn't it work when I put spaces around #3 or #4? Because outside of \ExplSyntaxOn...\ExplSyntaxOff, the _ character has a different catcode and is treated as a mathematical entity.

```
See https://tex.stackexchange.com/q/554706/218142.
```

See also https://tex.stackexchange.com/a/531037/218142.

```
802 \RenewDocumentCommand{\vec}{ s m e{_^} }{%
     \ensuremath{%
803
       \mbox{\ensuremath{\mbox{\%}}} 
 Note the \mbox{\ensuremath{\mbox{\backslash}}} , used to make superscript look better.
804
       \IfBooleanTF {#1}
                                  % check for *
805
806
          {\vv{#2}% % * gives an arrow
807
             % Use \sp{} primitive for superscript.
             % Adjust superscript for the arrow.
808
             809
         }%
810
         {\symbfit{#2} % no * gives us bold
811
             % Use sp{} primitive for superscript.
812
             % No superscript adjustment needed.
813
             \sp{\IfValueT{#4}{#4}\vphantom{\smash[t]{\big|}}}
814
         }%
815
       % Use \sb{} primitive for subscript.
816
       \style T{#3}{#3}\vphantom{\smash[b]{|}}}
817
     }%
818
819 }%
    The zero vector.
820 \NewDocumentCommand{\zerovec}{ s }{%
     \IfBooleanTF {#1}
821
       {\vv{0}}%
822
       {\symbfup{0}}%
823
824 }%
    A command for the change in a vector.
825 \NewDocumentCommand{\Dvec}{ s m }{%
     \Delta
826
     \IfBooleanTF{#1}
827
828
       {\vec*}%
829
       {\vec{\vec}}
     {#2}
830
831 }%
```

A command for the direction of a vector. We use a slight tweak is needed to get uniform hats that requires the makebox package.

See https://tex.stackexchange.com/a/391204/218142.

```
832 \NewDocumentCommand{\dirvec}{ s m }{%
833
     \widetilde{\mbox{(w\b)}}{\%}
        \ensuremath{%
834
          \IfBooleanTF{#1}%
835
            {#2}%
836
            {\symbfit{#2}}%
837
         }%
838
       }%
839
     }%
840
841 }%
    A command for the magnitude of a vector.
842 \NewDocumentCommand{\magvec}{ s m }{%
     \norm{%
843
844
       \IfBooleanTF{#1}
```

```
845 {\vec*}%
846 {\vec}%
847 {#2}
848 }%
849 }%
```

Intelligent commands for typesetting vector and tensor symbols and components suitable for use with both coordinate-free and index notations. Use starred form for index notation, unstarred form for coordinate-free.

```
850 \NewDocumentCommand{\veccomp}{ s m }{%
     % Consider renaming this to \vectorsym.
     \IfBooleanTF{#1}
     {\%} We have a *.
853
       \ensuremath{\symnormal{#2}}%
854
     }%
855
     {% We don't have a *.
856
       \ensuremath{\symbfit{#2}}%
857
858
     }%
859 }%
860 \NewDocumentCommand{\tencomp}{ s m }{%
     % Consider renaming this to \tensororsym.
861
     \IfBooleanTF{#1}
862
     {% We have a *.
863
864
       \ensuremath{\symsfit{#2}}%
     }%
865
     {% We don't have a *.
866
       \ensuremath{\symbfsfit{#2}}%
867
     }%
868
869 }%
    An environment for problem statements. The starred version allows for in-line lists.
870 \NewDocumentEnvironment{physicsproblem}{ m }{%
     \newpage%
871
     \section*{#1}%
872
873
     \newlist{parts}{enumerate}{2}%
     \setlist[parts]{label=\bfseries(\alph*)}}%
874
875
876 \NewDocumentEnvironment{physicsproblem*}{ m }{%
     \newpage%
877
     \section*{#1}%
878
     \newlist{parts}{enumerate*}{2}%
879
     \setlist[parts]{label=\bfseries(\alph*)}}%
880
     {}%
881
882 \NewDocumentCommand{\problempart}{}{\item}%
    An environment for problem solutions.
883 \NewDocumentEnvironment{physicssolution}{ +b }{%
     % Make equation numbering consecutive through the document.
884
     \begin{align}
885
       #1
886
     \end{align}
887
889 \NewDocumentEnvironment{physicssolution*}{ +b }{%
     % Make equation numbering consecutive through the document.
890
     \begin{align*}
891
       #1
892
     \end{align*}
893
894 }{}%
```

A simplified command for important images.

```
895 \NewDocumentCommand{\image}{ O{scale=1} m m m }{%
     \begin{figure}[ht!]
896
       \begin{center}%
897
         \includegraphics[#1]{#2}%
898
       \end{center}%
899
       \caption{#3}%
900
       \label{#4}%
     \end{figure}%
902
903 }%
    See https://tex.stackexchange.com/q/570223/218142.
904 \NewDocumentCommand{\reason}{ O{4cm} m }{&&\begin{minipage}{#1}\raggedright\small #2\end{minipage}}
    Notation for column and row vectors. \mivector→P.31 is a workhorse command.
 Orginal code provided by @egreg.
 See https://tex.stackexchange.com/a/39054/218142.
905 \ExplSyntaxOn
906 \NewDocumentCommand{\mivector}{ O{,} m o }%
907 {%
      \mi_vector:nn { #1 } { #2 }
908
      \IfValueT{#3}{\; {#3}}
909
910 }%
911 \seq_new:N \l__mi_list_seq
912 \cs_new_protected:Npn \mi_vector:nn #1 #2
913 {%
     \verb|\ensuremath{{\%}}|
914
915
       \seq_set_split:Nnn \l__mi_list_seq { , } { #2 }
       \int_compare:nF { \seq_count:N \l__mi_list_seq = 1 } { \left\langle }
916
       \seq_use: Nnnn \l__mi_list_seq { #1 } { #1 } { #1 }
917
       \int_compare:nF { \seq_count:N \l__mi_list_seq = 1 } { \right\rangle }
918
919
    }%
920 }%
921 \NewDocumentCommand{\colvec}{ O{,} m }{%
     \vector_main:nnnn { p } { \\ } { #1 } { #2 }
922
923 }%
924 \NewDocumentCommand{\rowvec}{ O{,} m }{%
     \vector_main:nnnn { p } { & } { #1 } { #2 }
925
926 }%
927 \seq_new:N \l__vector_arg_seq
928 \cs_new_protected:Npn \vector_main:nnnn #1 #2 #3 #4 {%
     \seq_set_split:Nnn \l__vector_arg_seq { #3 } { #4 }
     \begin{#1NiceMatrix}[r]
       \seq_use:Nnnn \l__vector_arg_seq { #2 } { #2 } { #2 }
931
     \end{#1NiceMatrix}
932
933 }%
934 \ExplSyntaxOff
    Commands for scientific notation.
935 \NewDocumentCommand{\tento}{ m }{\ensuremath{10^{#1}}}
936 \NewDocumentCommand{\timestento}{ m }{\ensuremath{\;\times\;\tento{#1}}}
937 \NewDocumentCommand{\xtento}{ m }{\ensuremath{\;\times\;\tento{#1}}}
938 \NewDocumentCommand{\changein}{}{\Delta}
    Intelligent delimiters provided via the mathtools package. Use the starred versions for fractions. You can supply optional
sizes. Note that default placeholders are used when the argument is empty.
939 \DeclarePairedDelimiterX{\norm}[1]{\lVert}{\rVert}{\ifblank{#1}{\:\cdot\:}{#1}}}
940 \DeclarePairedDelimiterX{\absv}[1]{\lvert}{\rvert}{\ifblank{#1}}{\:\cdot\:}{#1}}
941 \DeclarePairedDelimiterX{\angs}[1]{\langle}{\rangle}{\ifblank{#1}{\:\cdot\:}{#1}}
```

```
942 \DeclarePairedDelimiterX{\parentheses}[1]{()}{\ifblank{#1}{\:\cdot\:}{#1}} 943 \DeclarePairedDelimiterX{\dimensionsof}[1]{\lbrack}{\rbrack}{\ifblank{#1}{\:\cdot\:}{#1}} 944 \DeclarePairedDelimiterX{\unitsof}[1]{\lbrace}{\rbrace}{\ifblank{#1}{\:\cdot\:}{#1}}
```

Declare some new math operators. A \dim operator is already defined in amsmath. These may be more useful than delimiters.

```
945 \DeclareMathOperator{\abs}{abs} 946 \DeclareMathOperator{\units}{units}
```

These versions use \left...\right and are rather disfavored by IATEX purists. They may eventually be removed from mandi so don't rely on them.

```
947 \NewDocumentCommand{\innorm}{ O{\:\cdot\:} }{%
948
     \left\lVert#1\right\rVert
949 }%
950 \NewDocumentCommand{\inabsv}{ O(:\cdot) }{%
     \left\lvert#1\right\rvert
952 }%
953 \NewDocumentCommand{\inangs}{ O{\:\cdot\:} }{%
     \left\langle#1\right\rangle
954
955 }%
956 \NewDocumentCommand{\inpens}{ O{\:\cdot\:} }{%
     \left(#1\right)
957
958 }%
959 \NewDocumentCommand{\indims}{ O{\:\cdot\:} }{%
960
    \left[#1\right]
961 }%
962 \NewDocumentCommand{\inunts}{ O{\:\cdot\:} }{%
963
     \left\{#1\right\}
964 }%
    Command for highlighting parts of, or entire, mathematical expressions.
Original code by anonymous user @abcdefg, modified by me.
See https://texample.net/tikz/examples/beamer-arrows/.
See also https://tex.stackexchange.com/a/406084/218142.
See also https://tex.stackexchange.com/a/570858/218142.
See also https://tex.stackexchange.com/a/570789/218142.
See also https://tex.stackexchange.com/a/79659/218142.
See also https://tex.stackexchange.com/q/375032/218142.
See also https://tex.stackexchange.com/a/571744/218142.
965 \newcounter{tikzhighlightnode}
966 \NewDocumentCommand{\hilite}{ O{magenta!60} m O{rectangle} }{%
     \stepcounter{tikzhighlightnode}%
967
     \tikzmarknode{highlighted-node-\number\value{tikzhighlightnode}}{#2}%
968
     \edef\temp{%
969
       \noexpand\AddToShipoutPictureBG{%
970
         \noexpand\begin{tikzpicture}[overlay,remember picture]%
971
         972
          \noexpand\node[inner sep=1.0pt,fill=#1,#3,fit=(highlighted-node-\number\value{tikzhighlightnode})]{};%
973
974
         \noexpand\fi
         \noexpand\end{tikzpicture}%
975
       }%
976
     }%
977
978
     \temp%
979 }%
```

Intelligent slot command for coordinate-free tensor notation.

```
980 \NewDocumentCommand{\slot}{ s d[] }{% 981  % d[] must be used because of the way consecutive optional
```

```
982
     % arguments are handled. See xparse docs for details.
     \IfBooleanTF{#1}
983
     {\%} We have a *.
984
       \IfValueTF{#2}
985
       {% Insert a vector, but don't show the slot.
986
         \smash{\makebox[1.5em]{\ensuremath{#2}}}
987
988
       {% No vector, no slot.
989
         \smash{\makebox[1.5em]{\ensuremath{}}}
990
       }%
991
     }%
992
     {% We don't have a *.
993
       \IfValueTF{#2}
994
       {% Insert a vector and show the slot.
995
         \underline{\smash{\makebox[1.5em]{\ensuremath{#2}}}}
996
       }%
997
       {% No vector; just show the slot.
998
         \underline{\smash{\makebox[1.5em]{\ensuremath{}}}}
999
1000
       }%
1001
     }%
1002 }%
    Intelligent notation for contraction on pairs of slots.
1003 \NewDocumentCommand{\contraction}{ s m }{%
     \IfBooleanTF{#1}
1004
     {\mathbf C}}\ We have a *.
1005
     _{#2}
1007
1008 }%
    Intelligent differential (exterior derivative) operator.
1009 \NewDocumentCommand{\dd}{ s }{%
     \mathop{}\!
     \IfBooleanTF{#1}
1011
     {\symbfsfup{d}}% We have a *.
1012
     {\simeq d} We don't have a *.
1013
1014 }%
    Command to typeset tensor valence.
1015 \NewDocumentCommand{\valence}{ s m m }{%
     \IfBooleanTF{#1}
1016
1017
       \{(#2,#3)\}
1018
       {\binom{#2}{#3}}
1019 }%
    Diagnostic commands to provide sanity checks on commands that represent physical quantities and constants.
1020 \NewDocumentCommand{\checkquantity}{ m }{%
     % Works for both scalar and vector quantities.
1021
     \begin{center}
1022
       1023
         name & base & derived & alternate \tabularnewline
1024
1025
         \ttfamily\small{\expandafter\string\csname #1\endcsname} &
1026
         \small{\csname #1onlybaseunits\endcsname} &
         \small{\csname #1onlyderivedunits\endcsname} &
1027
         \small{\csname #1onlyalternateunits\endcsname}
1028
       \end{tabular}
1029
     \end{center}
1030
1031 }%
1032 \NewDocumentCommand{\checkconstant}{ m }{%
```

```
1033
     \begin{center}
1034
        \begin{tabular}{>(centering}p{4cm} >{\centering}p{3cm} >{\centering}p{4cm} >{\centering}p{3cm}}
1035
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