The mandi Package

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Acknowledgements

To all of the students who have learned LATEX in my introductory physics courses over the years, I say a heartfelt thank you. You have contributed directly to the state of this software and to its use in introductory physics courses and to innovating how physics is taught.

Change History

v3.0.0i											
General: Initial release.											6

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$\frac{1}{2}$	Image shown 20 percent actual size.	

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}

\mandiversion

Typesets the current version and build date.

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

The version is v3.0.0i dated 2021-03-18 and is a stable build.

1.2 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.

1.3 The mandisetup Command

N 2021-02-17

\mandisetup{\langle options \rangle}

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}

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

2 Student/Instructor Quick Guide

Use $\ensuremath{\mbox{$\veeec}}^{P.35}$ to typeset the symbol for a vector's magnitude. Use $\ensuremath{\mbox{$\backslash$dirvec$}}^{P.35}$ to typeset the symbol for a vector's direction. Use $\ensuremath{\mbox{$\backslash$changein$}}^{P.36}$ to typeset the symbol for the change in a vector or scalar. Use $\ensuremath{\mbox{$\backslashec}}^{P.35}$ to typeset the zero vector. Use $\ensuremath{\mbox{$\backslash$timestento$}}^{P.39}$ to typeset scientific notation.

Use a physical quantity's $^{-P.8}$ name to typeset a magnitude and that quantity's units. If the quantity is a vector, you can add vector either to the beginning or the end of the quantity's name. For example, if you want momentum, use \momentum $^{-P.8}$ and its variants.

Use a physical constant's P.22 name to typeset its numerical value and units. Append mathsymbol to the constant's name to get its mathematical symbol. For example, if you want to typeset the vacuum permittivity, use \vacuumpermittivity P.28 and its variant.

```
\(\vacuumpermittivitymathsymbol = \vacuumpermittivity \) \epsilon_{\rm o} = 9 \times 10^{-12} \, {\rm C}^2 \, / \, {\rm N} \cdot {\rm m}^2
```

Use $\mbox{\mbox{mivector}}^{P.36}$ to typeset symbolic vectors with components. Use the aliases $\mbox{\mbox{\mbox{direction}}}^{P.36}$ or $\mbox{\mbox{\mbox{\mbox{unitvector}}}^{P.36}}$ to typeset a direction or unit vector.

Use $physicsproblem^{\to P.40}$ and $parts^{\to P.40}$ and $problempart^{\to P.40}$ to typeset problems. Use $physicssolution^{\to P.41}$ to typeset step-by-step mathematical solutions. Use $glowscriptblock^{\to P.29}$ to typeset Glowscript programs. Use $physicsproblem^{\to P.32}$ to typeset programs to type programs to typeset programs to type programs to type programs to type programs to typeset programs to type programs to type programs to typeset programs to type programs to typ

3 Intelligent Commands for Physical Quantities and Constants

3.1 Physical Quantities

3.1.1 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.

N 2021-02-24

```
\label{local_momentum} $$\operatorname{magnitude}$ $$\operatorname{constant}(c_1,\ldots,c_n)$$ $$\operatorname{constant}(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 variant can take more than three components. Note the other variants for the quantity's value and units.

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

Commands that include the name of a physical quantity typeset units, so they shouldn't be used for algebraic or symbolic values of components. For example, one shouldn't use $\mbox{vectormomentum}(\mbox{mv}_x,\mbox{mv}_y,\mbox{mv}_z)$ but instead the generic $\mbox{mivector}(\mbox{mv}_x,\mbox{mv}_y,\mbox{mv}_z)$ instead.

3.1.2 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.

3.1.3 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 \(^{\top} P.36\) instead.

N 2021-02-24	$\label{eq:acceleration} $$\operatorname{acceleration}(magnitude)$$ \\ \operatorname{acceleration}(c_1,\dots,c_{n-1},\dots,c_{n-$, $c_n angle \}$		
	name	$\begin{array}{c} base \\ m \cdot s^{-2} \end{array}$	derived N/kg	$\begin{array}{c} {\rm alternate} \\ {\rm m/s^2} \end{array}$
	$\adjustlength{\mbox{\mbox{\backslash}}}$			
	name	base mol	derived mol	alternate mol
N 2021-02-24	\angularacceleration {\(magularacceleration \) vectorangularacceleration	$\mathbf{or}\{\langle c_1,\ldots,c_n \rangle\}$		
	${ m name}$ \angularacceleration	base $rad \cdot s^{-2}$	derived rad/s²	alternate rad/s²
	\((magnit)\)	ude }}		
	name \angularfrequency	base $rad \cdot s^{-1}$	derived rad/s	alternate rad/s
N 2021-02-24	lem:lem:lem:lem:lem:lem:lem:lem:lem:lem:	$,\ldots,c_{n}\rangle\}$		
	name \angularimpulse	$\begin{array}{c} base \\ m^2 \cdot kg \cdot s^{-1} \end{array}$	$\begin{array}{c} \text{derived} \\ \text{kg} \cdot \text{m}^2 \ / \ \text{s} \end{array}$	alternate $kg \cdot m^2 / s$
N 2021-02-24	lem:lem:lem:lem:lem:lem:lem:lem:lem:lem:	$_1$,, c_n \rangle $\}$		
	name	$\begin{array}{c} base \\ m^2 \cdot kg \cdot s^{-1} \end{array}$	$\frac{\text{derived}}{\text{kg} \cdot \text{m}^2 / \text{s}}$	alternate $kg \cdot m^2 / s$
N 2021-02-24	lem:lem:lem:lem:lem:lem:lem:lem:lem:lem:	$_1,\ldots,c_n angle \}$		
	${\rm name} \\ {\tt langularvelocity}$	base $rad \cdot s^{-1}$	derived rad/s	alternate rad/s
	$\area{(magnitude)}$			

base

 m^2

derived

 m^2

alternate

 m^2

alternate

Α

name

\area

name

\conventionalcurrent

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

\areachargedensity{\(magnitude \) \}

derived

C/s

base

A

	name \current	base A	derived A	alternate A
N 2021-02-24	$\label{lem:currentdensity} $$ \operatorname{currentdensity}(magnitude) $$ \operatorname{currentdensity}(c_1, cu$	\ldots , $c_n \rangle \}$		
	name \currentdensity	base m ⁻² ⋅A		$\begin{array}{c} {\rm alternate} \\ {\rm A}/{\rmm^2} \end{array}$
	$\verb \dielectricconstant{ } {\it agn}$	$itude angle \}$		
	name \dielectricconstant	base	derived	alternate
N 2021-02-24	$\label{lem:displacement} $$ \displacement{$\langle magnitude \rangle$} $$ \end{substitute} $$ \e$			
	name \displacement	base m	derived m	alternate m
	$\del{duration} {\del{magnitude}}$			
	name \duration	base s	derived s	alternate s
N 2021-02-24	$\label{lem:lem:matching} $$ \operatorname{lectricdipolemoment}(ma) $$ lect$	$\mathbf{or}\{\langle c_1, \dots, c_n \rangle\}$		
	name	$\begin{array}{c} \text{base} \\ \text{m} \cdot \text{s} \cdot \text{A} \end{array}$	derived $C \cdot m$	$\begin{array}{c} \text{alternate} \\ \text{C} \cdot \text{m} \end{array}$
N 2021-02-24	$\label{lem:continuous} $$ \operatorname{ctricfield}(magnitude) $$ \operatorname{ctricfield}(c_1,\ldots,c_n) $$ $$ \operatorname{ctricfield}(c_1,\ldots,c_n) $$ $$ $$ $$ $$ $$ $$ $$$	\ldots , $c_n \rangle \}$		
	name \electricfield	$\begin{array}{c} \text{base} \\ m \cdot kg \cdot s^{-3} \cdot A^{-1} \end{array}$	derived V/m	alternate N/C
	\electricflux {(magnitude)}			
	name	$\begin{array}{c} base \\ m^3 \cdot kg \cdot s^{-3} \cdot A^{-1} \end{array}$	derived V·m	alternate $N \cdot m^2$ / C
	\electricpotential { \langle magnitude}	tude angle brace		

	name \electricpotential	$\begin{array}{c} base \\ m^2 \cdot kg \cdot s^{-3} \cdot A^{-1} \end{array}$	derived V	alternate J/C
	\electroncurrent{\(magnite{c}\)	$ude \rangle \}$		
	name	$\begin{array}{c} \text{base} \\ \text{s}^{-1} \end{array}$	derived e/s	alternate e/s
	$\ensuremath{\mbox{emf}} \{\langle magnitude \rangle \}$			
	name \emf	$\begin{array}{c} base \\ m^2 \cdot kg \cdot s^{-3} \cdot A^{-1} \end{array}$	derived V	alternate J/C
	$\ensuremath{\mbox{energy}\{\langle magnitude\rangle\}}$			
	name \energy	$\begin{array}{c} base \\ m^2 \cdot kg \cdot s^{-2} \end{array}$	derived J	alternate J
	(magnitude	<i>⊵</i> }}		
	name \energydensity	$\begin{array}{c} base \\ m^{-1} \cdot kg \cdot s^{-2} \end{array}$	derived J/m³	$_{\rm J/m^3}^{\rm alternate}$
N 2021-02-24	$\label{eq:constraint} $$ \operatorname{cnergyflux}((magnitude)) $$ \operatorname{ctorenergyflux}((c_1,\dots, w_n)) $$ $$ $$ $$ $$ $$ $$ $$ $$$			
	name \energyflux	base $kg \cdot s^{-3}$	derived W/m ²	alternate W/m²
	$\ensuremath{\mbox{entropy}} {\mbox{(}magnitude\mbox{)}}$			
	name \entropy	$\begin{array}{c} base \\ m^2 \cdot kg \cdot s^{-2} \cdot K^{-1} \end{array}$	derived J/K	alternate J/K
N 2021-02-24	$\label{eq:constraint} $$ \left(\max(d_{i}) \right) $$ \left(c_{1}, \ldots, c_{n} \right) $$ \left(c_{1}, \ldots, c_{n} \right) $$$			
	name \force	$\begin{array}{c} base \\ m \cdot kg \cdot s^{-2} \end{array}$	derived N	alternate N
	\frequency{(magnitude)}			
	name \frequency	$\begin{array}{c} \text{base} \\ \text{s}^{-1} \end{array}$	derived Hz	alternate Hz

N 2021-02-24	\(magn\)gravitationalfieldvector\\vectorgravitationalfield	$\{\langle c_1, \dots, c_n \rangle\}$							
	${\rm name} \\ {\tt \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ $	base $m \cdot s^{-2}$	derived N/kg	alternate N/kg					
	\gravitationalpotential{\(magnitude\)}								
	$\begin{array}{c} \text{name} \\ \text{\colored} \end{array}$	base $m^2 \cdot s^{-2}$	derived J/kg	$\begin{array}{c} \text{alternate} \\ \text{J/kg} \end{array}$					
N 2021-02-24	$\label{eq:constraint} $$ \displaystyle \sup_{(magnitude)} $$ \operatorname{constant}_{(c_1,\dots,c_n)} $$ \operatorname{constant}_{(c_1,\dots,c_n)} $$$								
	name \impulse	$\begin{array}{c} base \\ m \cdot kg \cdot s^{-1} \end{array}$	$\begin{array}{c} \text{derived} \\ \text{N} \cdot \text{s} \end{array}$						
	\indexofrefraction{(magnitude)}								
	${\rm name} \\ {\bf \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ $	base	derived	alternate					
	\inductance {\(\langle magnitude \rangle \)}								
	name \inductance	$\begin{array}{c} base \\ m^2 \cdot kg \cdot s^{-2} \cdot A^{-2} \end{array}$	derived H	$\begin{array}{c} \text{alternate} \\ \text{V}\cdot\text{s}/\text{A} \end{array}$					
	\linearchargedensity{(magnitude)}								
	${\rm name} \\ {\tt linearchargedensity}$	$\begin{array}{c} base \\ m^{-1} \cdot s \cdot A \end{array}$	derived C/m	alternate C/m					
	(magni	$itude$ }}							
	${ m name} \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \$	$\begin{array}{c} {\rm base} \\ {\rm m}^{-1} \cdot {\rm kg} \end{array}$	derived kg/m	alternate kg/m					
	\luminous{\((magnitude\)\)}								
	name \luminous	base cd	derived cd	alternate cd					

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

	$ m name \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \$	base m·A							
N 2021-02-24	$\label{eq:local_magneticdipolemoment} $$\max_{a} \operatorname{local_magnitude} $$ \operatorname{local_magneticdipolemoment} \{\langle c_1, \dots, c_n \rangle \} $$ \operatorname{local_magneticdipolemoment} \{\langle c_1, \dots, c_n \rangle \}$$$								
	${\rm name} \\ {\tt \mbox{\tt \mbox{\tt }}} \\ {\tt \mbox$	$\begin{array}{c} base \\ m^2 \cdot A \end{array}$		alternate J/T					
N 2021-02-24	$\label{local-magnetic} $$\max_{magneticfield}(\alpha_1)$$ \end{constraints} $$\operatorname{constant}(c_1)$$$	$,\ldots,c_n\rangle\}$							
	name \magneticfield	$\begin{array}{c} \text{base} \\ \text{kg} \cdot \text{s}^{-2} \cdot \text{A}^{-1} \end{array}$	derived T						
	\langle magnitude	·)}							
	name \magneticflux	$\begin{array}{c} {\rm base} \\ {\rm m^2 \cdot kg \cdot s^{-2} \cdot A^{-1}} \end{array}$		$\begin{array}{c} \text{alternate} \\ \text{V} \cdot \text{s} \end{array}$					
	$\mbox{\mbox{$\mbox{mass}${(magnitude)}$}}$								
	name \mass	base kg	derived kg	alternate kg					
	$\mbox{\mbox{$\mbox{mobility}{($$\mbox{\mbo								
	name \mobility	$\begin{array}{c} base \\ m^2 \cdot kg \cdot s^{-4} \cdot A^{-1} \end{array}$	$\begin{array}{c} \text{derived} \\ m^2 / V \cdot s \end{array}$	alternate $(m/s)/(N/C)$					
	(magnit	$tude$ }}							
	name \momentofinertia	$\begin{array}{c} \text{base} \\ \text{m}^2 \cdot \text{kg} \end{array}$		$_{\text{kg}\cdot\text{m}^2}^{\text{alternate}}$					
N 2021-02-24	lem:lem:lem:lem:lem:lem:lem:lem:lem:lem:								
	name \momentum	$\begin{array}{c} {\rm base} \\ {m \cdot kg \cdot s^{-1}} \end{array}$	derived N·s						
N 2021-02-24	lem:lem:lem:lem:lem:lem:lem:lem:lem:lem:	\ldots , $c_n \rangle \}$							

${ m name}$ \relativepermeability	base	derived	alternate				
$\rdots = \frac{1}{2} (magnitude)$							
${ m name}$	base	derived	alternate				
$\verb \resistance { } (magnitude) $							
name \resistance	$\begin{array}{c} base \\ m^2 \cdot kg \cdot s^{-3} \cdot A^{-2} \end{array}$	derived V/A	$_{\Omega}^{\rm alternate}$				
\resistivity{(magnitude)}	ŀ						
name \resistivity	$\begin{array}{c} base \\ m^3 \cdot kg \cdot s^{-3} \cdot A^{-2} \end{array}$	$\frac{\mathrm{derived}}{\Omega \cdot \mathtt{m}}$	$\begin{array}{c} \text{alternate} \\ \left(\text{V} / \text{m} \right) / \left(\text{A} / \text{m}^2 \right) \end{array}$				
$\sl \mbox{solidangle} {\mbox{\sl} (magnitude)}$							
name \solidangle	$\begin{array}{c} base \\ m^2 \cdot m^{-2} \end{array}$	derived sr	alternate sr				
<r< td=""><td>$nagnitude \}$</td><td></td><td></td></r<>	$nagnitude \} $						
name \specificheatcapacity	$\begin{array}{c} base \\ m^2 \cdot s^{-2} \cdot K^{-1} \end{array}$	derived J/K·kg	$\frac{\text{alternate}}{\text{J/K} \cdot \text{kg}}$				
\springstiffness{\langle magnite}	ude }}						
name \springstiffness	base $kg \cdot s^{-2}$	derived N/m	alternate N/m				
$\springstretch{\langle magnitud \rangle}$	(e)}						
name \springstretch	base m	derived m	alternate m				
\stress{\(magnitude\)}							
name \stress	$\begin{array}{c} base \\ m^{-1} \cdot kg \cdot s^{-2} \end{array}$	derived Pa	alternate N/m²				
$\operatorname{\mathtt{\baseline}}(magnitude)$							
name \strain	base	derived	alternate				

	\tamparatura [(manamita, da)]			
	\temperature{\langle magnitude \range}			
	name \temperature	base K	derived K	alternate K
N 2021-02-24	$\begin{split} & \texttt{\torque}\{\langle magnitude \rangle\} \\ & \texttt{\torquevector}\{\langle c_1, \dots, c_n \rangle\} \\ & \texttt{\torque}\{\langle c_1, \dots, c_n \rangle\} \end{split}$			
	name \torque	$\begin{array}{c} base \\ m^2 \cdot kg \cdot s^{-2} \end{array}$		$\begin{array}{c} \text{alternate} \\ \text{N} \cdot \text{m} \end{array}$
N 2021-02-24 N 2021-02-24	$\label{eq:continuity} $$ \operatorname{coty}_{(magnitude)} $$ \operatorname{coty}_{(c_1,\dots,c_n)} $$ \operatorname{coty}_{(c_1,\dots,c_n)} $$ \operatorname{coty}_{(magnitude)} $$ \operatorname{coty}_{(c_1,\dots,c_n)} $$ \operatorname{coty}_{(c_1,\dots,c_n)} $$$			
	name \velocity	$\begin{array}{c} {\rm base} \\ {\rm m\cdot s^{-1}} \end{array}$	derived m/s	alternate m/s
	name \velocityc	base c	derived	$_{\rm c}^{\rm alternate}$
	$\vert \mbox{volume} \{ \langle magnitude \rangle \}$			
	name \volume	base m ³	derived m ³	$_{m^{3}}^{\mathrm{alternate}}$
	$\verb \volumechargedensity \{ \textit{magnit} \\$	$tude$ }}		
	${\rm name} \\ {\tt \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ $	$\begin{array}{c} \text{base} \\ \text{m}^{-3} \cdot \text{s} \cdot \text{A} \end{array}$	derived C/m³	alternate C/m ³
	$\verb \volumemassdensity \{ (magnitude) \} (magnitude) (m$	<i>le</i> }}		
	${ m name}$ \volumemassdensity	$\begin{array}{c} \text{base} \\ \text{m}^{-3} \cdot kg \end{array}$	$\begin{array}{c} \text{derived} \\ \text{kg} / \text{m}^3 \end{array}$	$\begin{array}{c} {\rm alternate} \\ {\rm kg/m^3} \end{array}$
	\wavelength{\lambda magnitude \range}			
	name \wavelength	base m	derived m	alternate m
N 2021-02-24	$\label{eq:local_angle_equation} $$ \operatorname{wavenumber}(\langle c_1, \dots, c_n \rangle) $$ \operatorname{vectorwavenumber}(\langle c_1, \dots, c_n \rangle) $$$			

name \wavenumber	base m ⁻¹	derived /m	alternate /m
$\work{(magnitude)}$			
name \work	$\begin{array}{c} {\rm base} \\ {\rm m^2 \cdot kg \cdot s^{-2}} \end{array}$	derived J	$\begin{array}{c} \text{alternate} \\ \text{N} \cdot \text{m} \end{array}$
\widtharpoonup	e>}		
name \youngsmodulus	$\begin{array}{c} base \\ m^{-1} \cdot kg \cdot s^{-2} \end{array}$	derived Pa	

3.1.4 Defining and Redefining Your Own Physical Quantities

N 2021-02-16 N 2021-02-21

Command to define/redefine a new/existing scalar quantity. If the derived or alternate units are omitted, they are defined to be the same as the base units. Do not use both this command and <code>\newvectorquantity</code> or <code>\renewvectorquantity</code> to define/redefine a quantity.

N 2021-02-16 N 2021-02-21

```
\newvectorquantity{\((name\))} \[\((derived units\))\] \[\((laternate units\))\] \[\((laternate units\))\] \[\((laternate units\))\]
```

Command to define/redefine a new/existing vector quantity. If the derived or alternate units are omitted, they are defined to be the same as the base units. Do not use both this command and <code>\newscalarquantity</code> or <code>\renewscalarquantity</code> to define/redefine a quantity.

3.1.5 Predefined Units and Constructs

```
\per
\usk
\emptyunit
\ampere
\atomicmassunit
\candela
\coulomb
\degree
\electronvolt
\farad
\henry
\hertz
\joule
\kelvin
\kilogram
\lightspeed
\meter
```

etre						
ole						
ewton						
hm						
ascal						
adian						
econd						
iemens						
teradian						
esla						
olt						
att						
eber						
othetwo						(postfix)
othethree						(postfix)
othefour						(postfix)
nverse						(postfix)
otheinversetwo						(postfix)
otheinversethree						(postfix)
otheinversefour						(postfix)
	etre ole ewton hm ascal adian econd iemens teradian esla olt att eber othetwo othethree othefour nverse otheinversethree otheinversefour	ole ewton hm ascal adian econd iemens teradian esla olt att eber othetwo othethree othefour nverse otheinversethree	ole ewton hm ascal adian econd iemens teradian esla olt att eber othetwo othethree othefour nverse otheinversethree	ole ewton hm ascal adian econd iemens teradian esla olt att eber othetwo othethree othefour nverse otheinversethree	ole ewton hm ascal adian econd iemens teradian esla olt att eber othetwo othethree othefour nverse otheinversethree	ole ewton hm ascal adian econd iemens teradian esla olt att eber othetwo othethree othefour nverse otheinversetwo otheinversethree

```
/
                                                          3 m/s
                                                          \per
                                //
                                                          Α
\usk
                                                          u
\unit{3}{\meter\per\second}
                                //
                                                          cd
\emptyunit
                                //
                                                          С
\ampere
\atomicmassunit
                                //
\candela
                                                          eV
                                //
\coulomb
                                                          F
\degree
\electronvolt
                                                          Η
                                \\
\\
\farad
                                                          Hz
\henry
                                                          J
                                //
\hertz
                                                          K
\joule
                                //
\kelvin
                                                          kg
\kilogram
                                //
                                                          С
                                11
\lightspeed
                                                          m
\meter
                                //
                                                          m
\metre
                                //
\mole
                                                          mol
                                \\
\\
\newton
                                                          N
\omega
                                                          \Omega
                                \\
\\
\pascal
                                                          Pa
\racklerightradian
                                //
\second
                                                          rad
                                //
\siemens
                                                          S
                                //
\steradian
                                                          S
\tesla
                                //
\volt
                                                          sr
\watt
                                                          T
\weber
                                                          V
\emptyunit\tothetwo
                                                          W
\emptyunit\tothethree
                                //
\emptyunit\tothefour
                                                          Wb
\emptyunit\inverse
                                //
                                                          \square^2
\emptyunit\totheinversetwo
                                                          \Box^3
\emptyunit\totheinversethree \\
                                                          \sqcap^4
\emptyunit\totheinversefour
                                                          \Box^{-2}
                                                          \Box^{-3}
                                                          \Box^{-4}
```

3.1.6 Changing Units

U 2021-02-26 U 2021-02-26 U 2021-02-26

```
\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.

U 2021-02-26 U 2021-02-26 U 2021-02-26

```
\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.

```
\label{eq:continuous_substitution} $$ \end{array} & 5 \end{array} & 6 \end{a
```

```
U 2021-02-26 | begin{usebaseunits} (use base units) | (environment content) |
| U 2021-02-26 | begin{usederivedunits} (use derived units) |
| (environment content) |
| (use derived units) |
| (use derived units) |
| (use derived units) |
| (environment content) |
| (use alternate units) |
| (environment content) |
| (environment content) |
| (end{usealternateunits}
```

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

```
\momentum{5}
                           11
\oofpez
                           11
\begin{usebaseunits}
                                                                                                  5 \,\mathrm{kg} \cdot \mathrm{m} \,/\,\mathrm{s}
   \momentum{5} \\
                                                                                                  9 \times 10^9 \,\mathrm{N} \cdot \mathrm{m}^2 \,/\,\mathrm{C}^2
   \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} / \text{F}
\end{usederivedunits}
                                                                                                  5 \,\mathrm{kg} \cdot \mathrm{m} \,/\,\mathrm{s}
\begin{usealternateunits}
                                                                                                  9 \times 10^9 \,\mathrm{N} \cdot \mathrm{m}^2 \,/\,\mathrm{C}^2
   \mbox{momentum{5} }
   \oofpez
\end{usealternateunits}
```

3.2 Physical Constants

3.2.1 Typesetting Physical Constants

Take the quantity $\frac{1}{4\pi\epsilon_0}$, 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 \,\mathrm{N} \cdot \mathrm{m}^2 \,/\,\mathrm{C}^2
                                                                                         9 \times 10^{9}
\oofpez
\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} \, / \, \text{F}
\oofpezalternateunits
                                                                                         9 \times 10^9 \,\mathrm{N} \cdot \mathrm{m}^2 \,/\,\mathrm{C}^2
\oofpezonlybaseunits
                                                                                         m^3 \cdot kg \cdot s^{-4} \cdot A^{-2}
\oofpezonlyderivedunits
\oofpezonlyalternateunits
                                                                                         m/F
                                                                                         N \cdot m^2 / C^2
```

3.2.2 Checking Physical Constants

U 2021-02-26

$\checkconstant{\langle name \rangle}$

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

3.2.3 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 $\colonbox{coulombconstant}^{P.23}$ and $\bcolonbox{biotsavartconstant}$ are defined as semantic aliases for, respectively, $\colonbox{pez}^{P.25}$ and $\colonbox{mzofp}^{P.25}$.

\avogadro			
name	base	derived	alternate
\avogadro symbol	$ m mol^{-1}$ approximate	/ mol precise	/ mol
N_A	6×10^{23}	$6.02214076 \times 10^{23}$	

N 2021-02-02

name \biotsavartconstant symbol $\frac{\mu_0}{4\pi}$	base $m \cdot kg \cdot s^{-2} \cdot A^{-2}$ approximate 10^{-7}	derived H/m precise 10 ⁻⁷	$\begin{array}{c} \text{alternate} \\ \text{T} \cdot \text{m} / \text{A} \end{array}$
\bohrradius			
name \bohrradius symbol a _o \boltzmann	base m approximate 5.3×10^{-11}	derived m precise $5.2917721067 \times 10^{-11}$	alternate m
\DOI CZMAIII			
name \boltzmann symbol k _B	base $m^2 \cdot kg \cdot s^{-2} \cdot K^{-1}$ approximate 1.4×10^{-23}	derived J/K precise 1.380649×10^{-23}	alternate J/K
\coulombconstant			
$\begin{array}{c} \text{name} \\ \texttt{\coulombconstant} \\ \text{symbol} \\ \frac{1}{4\pi\epsilon_{\text{o}}} \end{array}$	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			
name \earthmass symbol M _{Earth} \earthmoondistance	base kg approximate 6.0×10^{24}	derived kg precise 5.97237×10^{24}	alternate kg
$\begin{array}{c} \text{name} \\ \texttt{\ \ \ } \\ \texttt{\ \ \ } \\ \text{symbol} \\ \texttt{\ \ \ } \\ \texttt{\ \ \ } \\ \texttt{\ \ \ } \\ \texttt{\ \ } \\ \texttt{\ \ \ \ } \\ \texttt{\ \ \ } \\ \texttt{\ \ \ \ \ } \\ \texttt{\ \ \ \ \ \ } \\ \texttt{\ \ \ \ \ } \\ \texttt{\ \ \ \ \ } \\ \texttt{\ \ \ \ \ \ } \\ \texttt{\ \ \ \ \ } \\ \texttt{\ \ \ \ \ \ } \\ \texttt{\ \ \ \ \ } \\ \texttt{\ \ \ \ \ \ \ } \\ \texttt{\ \ \ \ \ \ } \\ \texttt{\ \ \ \ \ \ \ } \\ \texttt{\ \ \ \ \ \ \ } \\ \texttt{\ \ \ \ \ \ } \\ \texttt{\ \ \ \ \ \ \ \ } \\ \texttt{\ \ \ \ \ \ \ \ } \\ \texttt{\ \ \ \ \ \ \ } \\ \texttt{\ \ \ \ \ \ \ \ \ \ } \\ \texttt{\ \ \ \ \ \ \ \ } \\ \texttt{\ \ \ \ \ \ \ \ \ \ \ \ \ \ } \\ \texttt{\ \ \ \ \ \ \ \ \ \ \ } \\ \texttt{\ \ \ \ \ \ \ \ \ \ \ } \\ \texttt{\ \ \ \ \ \ \ \ \ \ } \\ \texttt{\ \ \ \ \ \ \ \ \ } \\ \texttt{\ \ \ \ \ \ \ } \\ \texttt{\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ } \\ \texttt{\ \ \ \ \ \ \ \ \ \ \ } \\ \texttt{\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ } \\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \$	base m approximate 3.8×10^8	derived m precise 3.81550×10^8	alternate m
\earthradius			
name \earthradius symbol R _{Earth}	base m approximate 6.4×10^6	derived m precise 6.371×10^6	alternate m

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\earthsundistance			
$\begin{array}{c} \text{name} \\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \$	base m approximate 1.5×10^{11}	derived m precise 1.496×10^{11}	alternate m
\electroncharge			
$\begin{array}{c} \text{name} \\ \texttt{\ \ } \texttt{\ }$	base $A \cdot s$ approximate -1.6×10^{-19}	derived C precise $-1.602176634 \times 10^{-19}$	alternate C
\electronCharge			
$\begin{array}{c} \text{name} \\ \texttt{\ \ } \texttt{\ }$	base $A \cdot s$ approximate -1.6×10^{-19}	derived C precise $-1.602176634 \times 10^{-19}$	alternate C
\electronmass			
$\begin{array}{c} \text{name} \\ \texttt{\ \ } \\ \texttt{\ } \\ \text{symbol} \\ \text{\ } \\ \text{\ } \\ \text{m}_{e} \end{array}$	base kg approximate 9.1×10^{-31}	derived kg precise $9.10938356 \times 10^{-31}$	alternate kg
\elementarycharge			
name \elementarycharge symbol e	base A·s approximate 1.6×10^{-19}	derived C precise $1.602176634 \times 10^{-19}$	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			
$\begin{array}{c} \text{name} \\ \texttt{\hydrogenmass} \\ \text{symbol} \\ \text{m}_{\text{H}} \end{array}$	base kg approximate 1.7×10^{-27}	derived kg precise $1.6737236 \times 10^{-27}$	alternate kg

\moonearthdistance			
$\begin{array}{c} \text{name} \\ \texttt{\moonearthdistance} \\ \text{symbol} \\ \text{d}_{\text{ME}} \end{array}$	base m approximate 3.8 × 10 ⁸	derived m precise 3.81550 × 10 ⁸	alternate m
\moonmass			
name \moonmass symbol M _{Moon}	base kg approximate 7.3×10^{22}	derived kg precise 7.342×10^{22}	alternate kg
\moonradius			
name \moonradius symbol R _{Moon}	base m approximate 1.7×10^6	derived m precise 1.7371 × 10 ⁶	alternate m
\mzofp			
name \mzofp symbol $\frac{\mu_o}{4\pi}$	base $m \cdot kg \cdot s^{-2} \cdot A^{-2}$ approximate 10^{-7}	derived H/m precise 10 ⁻⁷	$\begin{array}{c} \text{alternate} \\ \text{T} \cdot \text{m} / \text{A} \end{array}$
\neutronmass			
$\begin{array}{c} \text{name} \\ \texttt{\ \ } \\ \text{symbol} \\ \text{m}_{n} \end{array}$	base kg approximate 1.7×10^{-27}	derived kg precise $1.674927471 \times 10^{-27}$	alternate kg
\oofpez			
name \oofpez symbol $\frac{1}{4\pi\epsilon_0}$	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 $\frac{1}{4\pi\epsilon_{\rm o}{\rm c}^2}$	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 $J \cdot s$ precise $6.62607015 \times 10^{-34}$	
\planckbar			
name \planckbar symbol ħ	base $m^2 \cdot kg \cdot s^{-1}$ approximate 1.1×10^{-34}	derived J·s precise $1.054571817 \times 10^{-34}$	$\begin{array}{c} \text{alternate} \\ \text{J} \cdot \text{s} \end{array}$
\planckc			
name \planckc symbol hc	base $m^3 \cdot kg \cdot s^{-2}$ approximate 2.0×10^{-25}	derived	
\protoncharge			
$\begin{array}{c} \text{name} \\ \texttt{\protoncharge} \\ \text{symbol} \\ \text{\ensuremath{q_p}} \end{array}$	base A·s approximate $+1.6 \times 10^{-19}$	derived C precise $+1.602176634 \times 10^{-19}$	alternate C
\protonCharge			
name \protonCharge symbol Q _p	base A·s approximate $+1.6 \times 10^{-19}$	derived C precise $+1.602176634 \times 10^{-19}$	alternate C
\protonmass			
name \protonmass symbol m _p	base kg approximate 1.7×10^{-27}	derived kg precise $1.672621898 \times 10^{-27}$	alternate kg
\rydberg			
name \rydberg symbol R _∞	base m^{-1} approximate 1.1×10^7	derived m^{-1} precise $1.0973731568508 \times 10^{7}$	$_{m^{-1}}^{\mathrm{alternate}}$

\speedoflight			
name \speedoflight symbol c	base $m \cdot s^{-1}$ approximate 3×10^8	derived m/s precise 2.99792458×10^8	alternate m/s
\stefanboltzmann			
name \stefanboltzmann symbol σ	base $kg \cdot s^{-3} \cdot K^{-4}$ approximate 5.7×10^{-8}	derived	$\begin{array}{c} \text{alternate} \\ \text{W} / \text{m}^2 \cdot \text{K}^4 \end{array}$
\sunearthdistance			
$\begin{array}{c} \text{name} \\ \texttt{\sunearthdistance} \\ \text{symbol} \\ \text{d}_{\text{SE}} \end{array}$	base m approximate 1.5×10^{11}	derived m precise 1.496×10^{11}	alternate m
\sunradius			
name \sunradius symbol R _{Sun}	base m approximate 7.0×10^8	derived m precise 6.957×10^8	alternate m
\surfacegravfield			
name \surfacegravfield symbol g	base m·s ⁻² approximate 9.8	derived N/kg precise 9.807	alternate N/kg
\universalgrav			
name \universalgrav symbol G	base $m^3 \cdot kg^{-1} \cdot s^{-2}$ approximate 6.7×10^{-11}	derived $N \cdot m^2 / kg^2$ precise 6.67408×10^{-11}	$\begin{array}{c} \text{alternate} \\ N \cdot m^2 / kg^2 \end{array}$
\vacuumpermeability			
$\begin{array}{c} name \\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \$	base $m \cdot kg \cdot s^{-2} \cdot A^{-2}$ approximate $4\pi \times 10^{-7}$	derived H/m precise $4\pi \times 10^{-7}$	alternate T·m/A

\vacuumpermittivity

name base derived alternate \$\$\operatorname{vacuumpermittivity} \quad m^{-3} \cdot kg^{-1} \cdot s^4 \cdot A^2 \qquad F/m \qquad C^2/N \cdot m^2\$\$ symbol approximate precise \$\$\epsilon_0 \qquad 9 \times 10^{-12} \qquad 8.854187817 \times 10^{-12}\$\$

3.2.4 Defining and Redefining Your Own Physical Constants

N 2021-02-16

\newphysicalconstant {\((name\))}{\(\simpaproximate value\)}{\(\simpaproximate value\)}{\(\simpaproxim

N 2021-02-21

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

3.2.5 Changing 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 $\stackrel{\rightarrow}{}$ P.6 key.

N 2021-02-16 N 2021-02-16 \hereuseapproximateconstants{\(content\)}\hereusepreciseconstants{\(content\)}

Commands for setting the precision on the fly for a single instance.

N 2021-02-16

N 2021-02-16

\begin{useapproximateconstants}
 ⟨environment content⟩

(use approximate constants)

\end{useapproximateconstants}

\begin{usepreciseconstants}

(use precise constants)

⟨environment content⟩

\end{usepreciseconstants}

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

4 GlowScript and VPython Program Listings

4.1 The glowscriptblock Environment

U 2021-02-26

\begin{glowscriptblock} [(options)] ((link)) {(caption)} (GlowScript code) \end{glowscriptblock}

Code placed here is nicely formatted and optionally linked to its source on <code>GlowScript.org</code>. 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, <code>https://</code> is automatically prepended to the URL and can thus be omitted.

```
\begin{glowscriptblock}(tinyurl.com/y3lnqyn3){A \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 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 # kg# m Lo = 0.26ks = 1.8# N/m deltat = 0.01 # s10 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 spring = helix(pos=ceiling.pos, axis=ball.pos-ceiling.pos, 17 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 34 rate(100) # 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 + Fspring 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 GlowScript program and is on page 31.
```

4.2 The vpythonfile Command

U 2021-02-26

\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.

\vpythonfile[hyperurl interior = https://vpython.org]{vdemo.py}
{A \VPython\ program}

VPython Program 1: A VPython program from vpython import * 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 # 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 34 rate(100) # 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 + Fspring39 pball = pball + Fnet * deltat 40 ball.pos = ball.pos + (pball / mball) * deltat 41 spring.axis = ball.pos - ceiling.pos 42 t = t + deltat43

```
\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 33.
```

4.3 The glowscriptinline and vpythoninline Commands

U 2021-02-26 U 2021-02-26 $\begin{tabular}{ll} $$ \glowscriptinline{$\langle GlowScript\ code\rangle$} \\ \begin{tabular}{ll} $\langle VPython\ code\rangle$ \end{tabular}$

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 *.

5 Commands for Writing Physics Problem Solutions

In addition to the $glowscriptblock^{\rightarrow P.29}$ environment and the $\protect\operatorname{vpythonfile}^{\rightarrow P.32}$ command, the $\protect\operatorname{glowscriptinline}^{\rightarrow P.34}$ command, and $\protect\operatorname{vpythoninline}^{\rightarrow P.34}$ command 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.

5.1 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.

```
\label{labels} $$ \operatorname{(use\ this\ variant\ for\ boldface\ notation)} $$ \operatorname{(use\ this\ variant\ for\ boldface\ notation)} $$ \operatorname{(use\ this\ variant\ for\ arrow\ notation)} $$
```

Powerful and intelligent command for typesetting the direction of a vector. The options are the same as those for **\vec**.

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

Command for typesetting the zero vector. The starred variant gives arrow notation. Without the star you get boldface notation.

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

$\mbox{\mbox{\mbox{$\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*.

N 2021-02-21 N 2021-02-21

```
\label{limiter} $$ \operatorname{delimiter} {\langle c_1, \dots, c_n \rangle} $$ \operatorname{unitvector} {\langle delimiter \rangle} {\langle c_1, \dots, c_n \rangle} $$
```

Semantic aliases for \mivector.

\changein

Semantic alias for \Delta.

```
N 2021-02-21
                          \doublebars[\langle size \rangle] \{\langle quantity \rangle\}
                                                                                                                                                                       (double bars)
                                                                                                                                                   (double bars for fractions)
N 2021-02-21
                          \doublebars*[\langle size \rangle] \{\langle quantity \rangle\}
N 2021-02-21
                          \singlebars[\langle size \rangle] \{\langle quantity \rangle\}
                                                                                                                                                                        (single bars)
N 2021-02-21
                          \singlebars*[\langle size \rangle] \{\langle quantity \rangle\}
                                                                                                                                                    (single bars for fractions)
N 2021-02-21
                          \aglebrackets[\langle size \rangle] \{\langle quantity \rangle\}
                                                                                                                                                                   (angle brackets)
                          \anglebrackets*[\langle size \rangle] \{\langle quantity \rangle\}
                                                                                                                                               (angle brackets for fractions)
N 2021-02-21
N 2021-02-21
                          \parentheses[\langle size \rangle] \{\langle quantity \rangle\}
                                                                                                                                                                       (parentheses)
                          \operatorname{\mathtt{\baseline}} \{\langle \mathit{size} \rangle\} \{\langle \mathit{quantity} \rangle\}
                                                                                                                                                   (parentheses for fractions)
N 2021-02-21
N 2021-02-21
                          \squarebrackets[\langle size \rangle] \{\langle quantity \rangle\}
                                                                                                                                                                (square brackets)
N 2021-02-21
                          \squarebrackets*[\langle size \rangle] \{\langle quantity \rangle\}
                                                                                                                                             (square brackets for fractions)
N 2021-02-21
                          \colone{curlybraces} [\langle size \rangle] \{\langle quantity \rangle\}
                                                                                                                                                                      (curly braces)
```

N 2021-02-21

\curlybraces*[\(\size\)] {\(\langle quantity\rangle\)}

(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.

<pre>\[\] \[\doublebars{\vec{a}} \] \[\doublebars*{\frac{\vec{a}}{3}} \] \[\doublebars[\Bigg]{\frac{\vec{a}}{3}} \]</pre>	$\ \cdot\ $ $\ a\ $ $\left\ \frac{a}{3}\right\ $ $\left\ \frac{a}{3}\right\ $
<pre>\[\] \[\singlebars{x} \] \[\singlebars*{\frac{x}{3}} \] \[\singlebars[\Bigg]{\frac{x}{3}} \]</pre>	$\begin{vmatrix} \cdot \\ x \\ \left \frac{x}{3} \right \\ \left \frac{x}{3} \right \end{vmatrix}$
<pre>\[\] \[\anglebrackets{\vec{a}} \] \[\anglebrackets*{\frac{\vec{a}}{3}} \] \[\anglebrackets[\Bigg]{\frac{\vec{a}}{3}} \]</pre>	$\langle \cdot \rangle$ $\langle a \rangle$ $\left(\frac{a}{3}\right)$ $\left(\frac{a}{3}\right)$
<pre>\[\] \[\parentheses{x} \] \[\parentheses*{\frac{x}{3}} \] \[\parentheses[\Bigg]{\frac{x}{3}} \]</pre>	(\cdot) (x) $\left(\frac{x}{3}\right)$ $\left(\frac{x}{3}\right)$

```
N 2021-02-21
N 2021-02-21
N 2021-02-21
N 2021-02-21
N 2021-02-21
N 2021-02-21
```

```
\magnitude [\(\size\)] \{\(\quantity\)\} \quantity\} \quantity\}
```

Semantic aliases. Use \magnitude or \magnitude* to typeset the magnitude of a vector.

```
\begin{tabular}{ll} $$ \colvec [(delimiter)] {(c_1, ..., c_n)} \\ \colvec [(delimiter)] {(c_1, ..., c_n)} \end{tabular}
```

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. Units are not supported, so these are mainly for symbolic work.

```
 \begin{pmatrix} 1 \\ 2 \\ 3 \end{pmatrix}  \[ \colvec{1,2,3} \] \[ \rowvec{1,2,3} \] \[ \colvec{x_0,x_1,x_2,x_3} \] \[ \rowvec{x_0,x_1,x_2,x_3} \] \\[ \rowvec{x_0,x_1,x_2,x_3} \] \\ \[ \rowvec{x_0,x_1,x_2,x_3} \] \\ \[ \rowvec{x_0,x_1,x_2,x_3} \] \\ \( x_0 \\ x_1 \\ x_2 \\ x_3 \) \\ \( x_0 \\ x_1 \\ x_2 \\ x_3 \) \\ \( x_0 \\ x_1 \\ x_2 \\ x_3 \) \\ \( x_0 \\ x_1 \\ x_2 \\ x_3 \) \\ \( x_0 \\ x_1 \\ x_2 \\ x_3 \) \\ \( x_0 \\ x_1 \\ x_2 \\ x_3 \) \\ \( x_0 \\ x_1 \\ x_2 \\ x_3 \) \\ \( x_0 \\ x_1 \\ x_2 \\ x_3 \) \\ \( x_0 \\ x_1 \\ x_2 \\ x_3 \) \\ \( x_0 \\ x_1 \\ x_2 \\ x_3 \) \\ \( x_0 \\ x_1 \\ x_2 \\ x_3 \) \\ \( x_0 \\ x_1 \\ x_2 \\ x_3 \) \\ \( x_0 \\ x_1 \\ x_2 \\ x_3 \) \\ \( x_0 \\ x_1 \\ x_2 \\ x_3 \) \\ \( x_0 \\ x_1 \\ x_2 \\ x_3 \) \\ \( x_0 \\ x_1 \\ x_2 \\ x_3 \) \\ \( x_0 \\ x_1 \\ x_2 \\ x_3 \) \\ \( x_0 \\ x_1 \\ x_2 \\ x_3 \) \\ \( x_0 \\ x_1 \\ x_2 \\ x_3 \) \\ \( x_0 \\ x_1 \\ x_2 \\ x_3 \) \\ \( x_0 \\ x_1 \\ x_2 \\ x_3 \) \\ \( x_0 \\ x_1 \\ x_2 \\ x_3 \) \\ \( x_0 \\ x_1 \\ x_2 \\ x_3 \) \\ \( x_0 \\ x_1 \\ x_2 \\ x_3 \) \\ \( x_0 \\ x_1 \\ x_2 \\ x_3 \) \\ \( x_0 \\ x_1 \\ x_2 \\ x_3 \) \\ \( x_0 \\ x_1 \\ x_2 \\ x_3 \) \\ \( x_0 \\ x_1 \\ x_2 \\ x_3 \) \\ \( x_0 \\ x_1 \\ x_2 \\ x_3 \) \\ \( x_0 \\ x_1 \\ x_2 \\ x_3 \) \\ \( x_0 \\ x_1 \\ x_2 \\ x_3 \) \\ \( x_0 \\ x_1 \\ x_2 \\ x_3 \) \\ \( x_0 \\ x_1 \\ x_2 \\ x_3 \) \\ \( x_0 \\ x_1 \\ x_2 \\ x_3 \) \\ \( x_0 \\ x_1 \\ x_2 \\ x_3 \) \\ \( x_0 \\ x_1 \\ x_2 \\ x_3 \) \\ \( x_0 \\ x_1 \\ x_2 \\ x_3 \) \\ \( x_0 \\ x_1 \\ x_2 \\ x_3 \) \\ \( x_0 \\ x_1 \\ x_2 \\ x_3 \) \\ \( x_0 \\ x_1 \\ x_2 \\ x_3 \) \\ \( x_0 \\ x_1 \\ x_2 \\ x_3 \) \\ \( x_0 \\ x_1 \\ x_2 \\ x_3 \) \\ \( x_0 \\ x_1 \\ x_2 \\ x_3 \) \\ \( x_0 \\ x_1 \\ x_2 \\ x_3 \) \\ \( x_0 \\ x_1 \\ x_2 \\ x_3 \) \\ \( x_0 \\ x_1 \\ x_2 \\ x_3 \) \\ \( x_0 \\ x_1 \\ x_2 \\ x_3 \) \\ \( x_0 \\ x_1 \\ x_2 \\ x_3 \) \\ \( x_0 \\ x_1 \\ x_2 \\ x_3 \)
```

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

Commands for powers of ten and scientific notation.

5.2 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)

      \tencomp*{(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
```

```
\valence{(index)}{(index)}
\valence*{(index)}{(index)}
```

Typesets tensor valence. The starred variant typesets it horizontally.

```
A vector is a \(\valence{1}{0}\\) tensor. \\
A vector is a \(\valence*{1}{0}\\) tensor.

A vector is a \(\valence*{1}{0}\\) tensor.

A vector is a \((\valence*{1}{0}\\)) tensor.
```

```
\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.

```
\mathbb{C}_{1,2}
\(\contraction{1,2}\)\\
                                                              C_{1,2}
\(\contraction*{1,2}\)
```

```
\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}])
                                                      (<u>a</u>)
\( (\slot*) \)
                                                      ( )
\( (\slot*[\vec{a}]) \)
                                                      (a)
```

5.3 Problems and Annotated Problem Solutions

N 2021-02-03

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 $\langle problem \rangle$ \end{physicsproblem} \begin{physicsproblem*}{\langle title \rangle} (problem)

(use this variant for in-line lists)

(use this variant for vertical lists)

\end{physicsproblem*} \begin{parts} {\langle title \rangle}

\begin{physicsproblem}{\langle title \rangle}

(provides problem parts)

⟨problem⟩

\end{parts}

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.

N 2012-02-03

\problempart

Denotes a part of a problem within a parts environment.

```
\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{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 2021-02-26

U 2021-02-26

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 2012-02-26

\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 $^{\rightarrow P.41}$ 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.

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

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

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

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

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

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

U 2021-02-26

$\label{limits} $$ \mbox{image} [(options)] {(caption)} {(label)} {(image)} $$$

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}
```

1×1
(Congrad size: 2001-200 kp)

Figure 1: Image shown 20 percent actual size.

```
Figure \ref{reffig1} is nice.
It's captioned \nameref{reffig1} and is on page \pageref{reffig1}.

Figure 1 is nice. It's captioned Image shown 20 percent actual size and is on page 44.
```

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



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

Figure $\rffig2$ is nice. It's captioned $\nmeref{reffig2}$ and is on page $\pageref{reffig2}$.

Figure 2 is nice. It's captioned Image shown 20 percent actual size and rotated and is on page 45.

6 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.

6.1 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}_{\mathrm{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}}
\(\lhsmomentumprinciple*\)
\(\rhsmomentumprinciple*\)
                                                                                               \vec{F}_{\rm sys,net} \Delta t
\( \lhsmomentumprincipleupdate* \)
                                                                                               \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}_{\text{sys,final}} = \overrightarrow{p}_{\text{sys,initial}} + \overrightarrow{F}_{\text{sys,net}} \Delta t
```

6.2 The Energy Principle

```
\lhsenergyprinciple (LHS of delta form) \rhsenergyprinciple[\((\rho\) process...\)] (RHS of delta form) \lhsenergyprincipleupdate (LHS of update form)
```

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

```
\rhsenergyprincipleupdate[\(\rhoreverthing\)] (RHS of update form)
\energyprinciple[\(\rhoreverthing\)] (delta form)
\energyprincipleupdate[\(\rhoreverthing\)] (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}
                                                                                                  \begin{split} E_{\text{sys,final}} &= E_{\text{sys,initial}} + W_{\text{ext}} \\ &= E_{\text{sys,initial}} + W_{\text{ext}} + Q \\ &= E_{\text{sys,final}} = E_{\text{sys,initial}} + W_{\text{ext}} \\ &= E_{\text{sys,final}} = E_{\text{sys,initial}} + W_{\text{ext}} + Q \end{split}
\(\rhsenergyprincipleupdate\)
\(\rhsenergyprincipleupdate[+Q]\)
\(\energyprincipleupdate\)
\(\energyprincipleupdate[+Q]\)
```

6.3 The Angular Momentum Principle

```
(LHS of delta form, bold vectors)
\lhsangularmomentumprinciple
                                                                (RHS of delta form, bold vectors)
\rhsangularmomentumprinciple
\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
\(\angularmomentumprinciple\)
                                                                                    //
\( \angularmomentumprincipleupdate \)
\( \langularmomentumprinciple* \)
                                                                                    //
                                                                                                          \Delta \overline{L}_{A, \mathrm{sys, net}}
\(\rhsangularmomentumprinciple*\)
                                                                                                          \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
\( \angularmomentumprinciple* \)
\(\angularmomentumprincipleupdate* \)
```

6.4 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.

```
\(\restenergy\)\\ \(\restenergy[\symup{final}]\) E_{\rm rest} = E_{\rm rest,final}
```

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.

\(\thermalenergy\)\\ \(\thermalenergy[\symup{final}]\)	$E_{\rm therm} \\ E_{\rm therm,final}$
--	--

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 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

\t rotationalkineticenergy [$\langle label \rangle$]

$\triangle \triangle \tri$

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

$\gravitational potential energy [\langle label \rangle]$

Symbol for gravitational potential energy.

```
\(\gravitationalpotentialenergy\)\\ \(\gravitationalpotentialenergy[\symup{final}]\) U_{\rm g} = U_{\rm 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}
```

7 Source Code

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{3.0.0i}
2 \def\mandi@Date{2021-03-18}
3 \NeedsTeXFormat{LaTeX2e}[1999/12/01]
4 \providecommand\DeclareRelease[3]{}
5 \providecommand\DeclareCurrentRelease[2]{}
6 \DeclareRelease{v3.0.0i}{2021-03-18}{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.
10 \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 LATEX kernel. Because unicode-math is required, all documents using mandi
must be compiled with an engine that supports Unicode. We recommend LuaLATEX.
11 \RequirePackage{unicode-math}
12 \unimathsetup{math-style=ISO}
13 \unimathsetup{warnings-off={mathtools-colon,mathtools-overbracket}}
14 \setmathfont[Scale=MatchLowercase] {TeX Gyre DejaVu Math} % single-storey g.
   Use normal math letters from Latin Modern Math for familiarity with textbooks.
15 \setmathfont[Scale=MatchLowercase,range=it/]{Latin Modern Math}
   Borrow mathscr and mathbfscr from XITS Math.
See https://tex.stackexchange.com/a/120073/218142.
```

16 \setmathfont[Scale=MatchLowercase,range={\mathscr,\mathbfscr}]{XITS Math}

Get original and bold mathcal fonts.

See https://tex.stackexchange.com/a/21742/218142.

17 \setmathfont[Scale=MatchLowercase, range={\mathcal,\mathbfcal},StylisticSet=1]{XITS Math}

Borrow Greek letters from Latin Modern Math.

```
\label{thm:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:cont:eq:c
```

Load third party packages, documenting why each one is needed.

```
23 \RequirePackage{amsmath}
                                        % AMS goodness (don't load amssymb or amsfonts)
24 \RequirePackage[inline] {enumitem}
                                        % needed for physicsproblem environment
25 \RequirePackage{eso-pic}
                                        % needed for \hilite
26 \RequirePackage[g]{esvect}
                                        % needed for nice vector arrow, style g
27 \RequirePackage{pgfopts}
                                        % needed for key-value interface
28 \RequirePackage{array}
                                        % needed for \checkquantity and \checkconstant
                                        % needed for requiring LuaLaTeX
29 \RequirePackage{iftex}
30 \RequirePackage{makebox}
                                        % needed for consistent \dirvect; \makebox
31 \RequirePackage{mathtools}
                                        % needed for paired delimiters; extends amsmath
32 \RequirePackage{nicematrix}
                                        \% needed for column and row vectors
33 \RequirePackage[most]{tcolorbox}
                                        % needed for program listings
34 \RequirePackage{tensor}
                                        % needed for index notation
35 \RequirePackage{tikz}
                                        % needed for \hilite
```

```
36 \usetikzlibrary{shapes,fit,tikzmark} % needed for \hilite 37 \RequirePackage{hyperref} % load last 38 \RequireLuaTeX % require this engine
```

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

```
39 \DeclareFontFamily{U}{esvect}{}
40 \DeclareFontShape{U}{esvect}{m}{n}{%
    <-5.5> vect5
41
42
    <5.5-6.5> vect6
    <6.5-7.5> vect7
44
    <7.5-8.5> vect8
    <8.5-9.5> vect9
45
   <9.5-> vect10
46
47 }{}%
48 \directlua{%
49 luaotfload.add_colorscheme("colordigits",
     {["8000FF"] = {"one","two","three","four","five","six","seven","eight","nine","zero"}})
51 }%
52 \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.

```
53 \newfontfamily{\gsfontfamily}{DejaVuSansMono}
                                                                                                            % new font for listings
54 \definecolor{gsbggray}
                                                              {rgb}{0.90,0.90,0.90} % background gray
55 \definecolor{gsgray}
                                                              \{rgb\}\{0.30,0.30,0.30\} % gray
56 \definecolor{gsgreen}
                                                              {rgb}{0.00,0.60,0.00} % green
57 \definecolor{gsorange}
                                                              {rgb}{0.80,0.45,0.12} % orange
58 \label{lem:second} $ \align{ } $ \ali
                                                              \{rgb\}\{1.00,0.90,0.71\} % peach
59 \definecolor{gspearl}
                                                              {rgb}{0.94,0.92,0.84} % pearl
60 \definecolor{gsplum}
                                                              {rgb}{0.74,0.46,0.70} % plum
61 \lstdefinestyle{vpython}{%
                                                                                                            % style for listings
62
         backgroundcolor=\color{gsbggray},%
                                                                                                            % background color
63
         basicstyle=\colordigits\footnotesize,%
                                                                                                            % default style
         breakatwhitespace=true%
64
                                                                                                            % break at whitespace
65
         breaklines=true,%
                                                                                                            % break long lines
66
         captionpos=b,%
                                                                                                            % position caption
                                                                                                            % STILL DON'T UNDERSTAND THIS
67
         classoffset=1,%
         commentstyle=\color{gsgray},%
68
                                                                                                            % font for comments
69
         deletekeywords={print},%
                                                                                                            % delete keywords from the given language
         emph={self,cls,@classmethod,@property},%
                                                                                                            % words to emphasize
70
         emphstyle=\color{gsorange}\itshape,%
                                                                                                            % font for emphasis
71
         escapeinside={(*0}{0*)},%
72
                                                                                                            % add LaTeX within your code
73
         frame=tb,%
                                                                                                            % frame style
         framerule=2.0pt,%
                                                                                                            % frame thickness
74
75
         framexleftmargin=5pt,%
                                                                                                            % extra frame left margin
         %identifierstyle=\sffamily,%
76
                                                                                                              % style for identifiers
         keywordstyle=\gsfontfamily\color{gsplum},%
                                                                                                            % color for keywords
77
         language=Python,%
                                                                                                            % select language
78
         linewidth=\linewidth,%
                                                                                                            % width of listings
79
                                                                                                            % VPython/GlowScript specific keywords
         morekeywords={%
80
             __future__,abs,acos,align,ambient,angle,append,append_to_caption,%
81
             append to title, arange, arrow, asin, astuple, atan, atan2, attach arrow, %
82
             attach_trail,autoscale,axis,background,billboard,bind,black,blue,border,%
83
             bounding_box,box,bumpaxis,bumpmap,bumpmaps,camera,canvas,caption,capture,%
84
             ceil,center,clear,clear_trail,click,clone,CoffeeScript,coils,color,combin,%
85
             comp,compound,cone,convex,cos,cross,curve,cyan,cylinder,data,degrees,del,%
86
```

```
delete, depth, descender, diff angle, digits, division, dot, draw complete, %
87
       ellipsoid.emissive.end face color.equals.explog.extrusion.faces.factorial.%
88
       False, floor, follow, font, format, forward, fov, frame, gcurve, gdisplay, gdots, %
89
       get_library,get_selected,ghbars,global,GlowScript,graph,graphs,green,gvbars,%
90
       hat, headlength, headwidth, height, helix, hsv_to_rgb, index, interval, keydown, %
91
       keyup, label, length, lights, line, linecolor, linewidth, logx, logy, lower left, %
92
93
       lower_right, mag, mag2, magenta, make_trail, marker_color, markers, material, %
       max, min, mouse, mousedown, mousemove, mouseup, newball, norm, normal, objects, %
94
       offset, one, opacity, orange, origin, path, pause, pi, pixel_to_world, pixels, plot, %
95
       points, pos, pow, pps, print, print function, print options, proj, purple, pyramid, %
96
       quad, radians, radius, random, rate, ray, read_local_file, readonly, red, redraw, %
97
       retain, rgb_to_hsv, ring, rotate, round, scene, scroll, shaftwidth, shape, shapes, %
98
       shininess, show_end_face, show_start_face, sign, sin, size, size_units, sleep, %
99
       smooth, space, sphere, sqrt, start, start_face_color, stop, tan, text, textpos, %
100
       texture, textures, thickness, title, trail_color, trail_object, trail_radius, %
101
       trail_type,triangle,trigger,True,twist,unbind,up,upper_left,upper_right,%
102
       userpan, userspin, userzoom, vec, vector, vertex, vertical_spacing, visible, %
103
       visual, vpython, VPython, waitfor, white, width, world, xtitle, yellow, yoffset, %
104
105
       ytitle%
106
     },%
     morekeywords={print,None,TypeError},%
                                                    % additional keywords
107
     morestring=[b]{"""},%
                                                    % treat triple quotes as strings
108
     numbers=left,%
                                                    % where to put line numbers
109
     numbersep=10pt,%
                                                    % how far line numbers are from code
110
                                                    % set to 'none' for no line numbers
     numberstyle=\bfseries\tiny,%
111
     showstringspaces=false,%
                                                    % show spaces in strings
112
113
     showtabs=false,%
                                                    % show tabs within strings
     stringstyle=\gsfontfamily\color{gsgreen},% % color for strings
114
     upquote=true,%
                                                    % how to typeset quotes
115
116 }%
    Introduce a new, more intelligent glowscriptblock<sup>→ P. 29</sup> environment.
117 \NewTCBListing[auto counter,list inside=gsprogs]{glowscriptblock}
     { O{} D(){glowscript.org} m }{%
     breakable,%
119
120
     center,%
     code = \newpage,%
121
     %derivpeach,%
122
123
     enhanced, %
     hyperurl interior = https://#2,%
124
     label = {gs:\thetcbcounter},%
125
126
     left = 8mm, %
127
     list entry = \thetcbcounter~~~#3,%
128
    listing only,%
129
    listing style = vpython,%
    nameref = \{#3\},%
     title = \texttt{GlowScript} Program \thetcbcounter: #3,%
    width = 0.9\textwidth,%
133
    {#1},
134 }%
    A new command for generating a list of GlowScript programs.
135 \NewDocumentCommand{\listofglowscriptprograms}{}{\tcblistof[\section*]{gsprogs}
    {List of \texttt{GlowScript} Programs}}%
    Introduce a new, more intelligent \vpythonfile \rightarrow P. 32 command.
137 \NewTCBInputListing[auto counter, list inside=vpprogs] {\vpythonfile}
    \{ 0\{\} m m \}\{\%
139
     breakable,%
```

```
center,%
140
141
     code = \newpage,%
     %derivgray,%
142
143
     enhanced,%
     hyperurl interior = https://,%
144
     label = {vp:\thetcbcounter},%
145
     left = 8mm, %
     list entry = \thetcbcounter~~~#3,%
147
    listing file = {#2},%
148
     listing only,%
149
     listing style = vpython,%
150
     nameref = \{\#3\},%
151
     title = \texttt{VPython} Program \thetcbcounter: #3,%
     width = 0.9\textwidth,%
154
     {#1},%
155 }%
    A new command for generating a list of VPython programs.
156 \NewDocumentCommand{\listofvpythonprograms}{}{\tcblistof[\section*]{vpprogs}
     {List of \texttt{VPython} Programs}}%
    Introduce a new \glowscriptinline \rightarrow P. 34 command.
158 \DeclareTotalTCBox{\glowscriptinline}{ m }{%
     bottom = Opt,%
159
     bottomrule = 0.0mm,%
160
161
     boxsep = 1.0mm,%
     colback = gsbggray,%
162
     colframe = gsbggray,%
163
     left = Opt,%
164
     leftrule = 0.0mm,%
165
     nobeforeafter,%
166
     right = Opt,%
167
     rightrule = 0.0mm,%
     sharp corners,%
169
170
     tcbox raise base,%
     top = Opt,%
171
     toprule = 0.0mm,%
172
173 }{\lstinline[style = vpython]{#1}}%
    Define \vpythoninline \(^{\text{P}}\). 34, a semantic alias for VPython in-line listings.
174 \NewDocumentCommand{\vpythoninline}{}{\glowscriptinline}%
the now outdated Slunits package. We make use of \symup{...} from the unicode-math package.
```

Define units to be used with the unit engine. All single letter macros are now gone. We basically absorbed and adapted

```
175 \NewDocumentCommand{\per}{}\ensuremath{\,/\,}}
176 \NewDocumentCommand{\usk}{}{\ensuremath{\,\cdot\,}}
177 \NewDocumentCommand{\unit}{ m m }{\ensuremath{{#1}\;{#2}}}
178 \NewDocumentCommand{\ampere}{}{\ensuremath{\symup{A}}}}
179 \end{atomic mass unit} {} {\ensuremath {\symup {u}}} }
180 \NewDocumentCommand{\candela}{}\ensuremath{\symup{cd}}}
181 \NewDocumentCommand{\coulomb}{}{\ensuremath{\symup{C}}}}
182 \NewDocumentCommand{\degree}{}{\ensuremath{^{\circ}}}
183 \NewDocumentCommand{\electronvolt}{}{\ensuremath{\symup{eV}}}}
184 \ensuremath{\symup{F}}}
185 \NewDocumentCommand{\henry}{}{\ensuremath{\symup{H}}}}
186 \NewDocumentCommand{\hertz}{}{\ensuremath{\symup{Hz}}}
187 \NewDocumentCommand{\joule}{}{\ensuremath{\symup{J}}}}
188 \NewDocumentCommand{\kelvin}{}{\ensuremath{\symup{K}}}}
189 \NewDocumentCommand{\kilogram}{}{\ensuremath{\symup{kg}}}
```

```
190 \NewDocumentCommand{\lightspeed}{}{\ensuremath{\symup{c}}}
191 \NewDocumentCommand{\meter}{}{\ensuremath{\symup{m}}}
192 \NewDocumentCommand{\metre}{}{\meter}
193 \NewDocumentCommand{\mole}{}{\ensuremath{\symup{mol}}}
194 \NewDocumentCommand{\newton}{}{\ensuremath{\symup{N}}}
195 \NewDocumentCommand{\ohm}{}{\ensuremath{\symup\Omega}}
196 \NewDocumentCommand{\pascal}{}{\ensuremath{\symup{Pa}}}
197 \NewDocumentCommand{\radian}{}{\ensuremath{\symup{rad}}}}
198 \NewDocumentCommand{\second}{}{\ensuremath{\symup{s}}}
199 \MewDocumentCommand{\siemens}{}{\ensuremath{\symup{S}}}
200 \NewDocumentCommand{\steradian}{}{\ensuremath{\symup{sr}}}
201 \NewDocumentCommand{\tesla}{}{\ensuremath{\symup{T}}}}
202 \NewDocumentCommand{\volt}{}{\ensuremath{\symup{V}}}}
203 \NewDocumentCommand{\watt}{}{\ensuremath{\symup{W}}}}
204 \NewDocumentCommand{\weber}{}{\ensuremath{\symup{Wb}}}
205 \NewDocumentCommand{\tothetwo}{}{\ensuremath{^2}}
                                                                   % postfix 2
206 \NewDocumentCommand{\tothethree}{}{\ensuremath{^3}}
                                                                   % postfix 3
207 \MewDocumentCommand{\tothefour}{}{\ensuremath{^4}}
                                                                   % postfix 4
208 \NewDocumentCommand{\inverse}{}{\column{-1}}}
                                                                   % postfix -1
209 \NewDocumentCommand{\totheinversetwo}{}{\ensuremath{^{-2}}}
                                                                   % postfix -2
210 \NewDocumentCommand{\totheinversethree}{}{\ensuremath{^{-3}}}} % postfix -3
211 \NewDocumentCommand{\totheinversefour}{}\ensuremath{^{-4}}} % postfix -4
212 \NewDocumentCommand{\emptyunit}{}{\ensuremath{\mdlgwhtsquare}}
    The core unit engine has been completely rewritten in expl3 for both clarity and power.
    Generic internal selectors.
213 \newcommand*{\mandi@selectunits}{}
214 \newcommand*{\mandi@selectprecision}{}
    Specific internal selectors.
215 \newcommand*{\mandi@selectapproximate}[2]{#1}
                                                      % really \@firstoftwo
216 \newcommand*{\mandi@selectprecise}[2]{#2}
                                                      % really \@secondoftwo
217 \newcommand*{\mandi@selectbaseunits}[3]{#1}
                                                      % really \Offirstofthree
218 \newcommand*{\mandi@selectderivedunits}[3]{#2}
                                                      % really \@secondofthree
219 \newcommand*{\mandi@selectalternateunits}[3]{#3} % really \@thirdofthree
    Document level global switches.
220 \NewDocumentCommand{\alwaysusebaseunits}{}
     {\renewcommand*{\mandi@selectunits}{\mandi@selectbaseunits}}%
222 \NewDocumentCommand{\alwaysusederivedunits}{}
     {\renewcommand*{\mandi@selectunits}{\mandi@selectderivedunits}}%
224 \NewDocumentCommand{\alwaysusealternateunits}{}
     {\renewcommand*{\mandi@selectunits}{\mandi@selectalternateunits}}%
226 \NewDocumentCommand{\alwaysuseapproximateconstants}{}
     {\renewcommand*{\mandi@selectprecision}{\mandi@selectapproximate}}%
228 \NewDocumentCommand{\alwaysusepreciseconstants}{}
     {\tt \{\normand*{\tt \{\normand*{\tt \{\normand: \&clectprecision\}{\tt \{\normand: \&clectprecise\}}\}\%}}
229
    Document level localized variants.
230 \NewDocumentCommand{\hereusebaseunits}{ m }{\begingroup\alwaysusebaseunits#1\endgroup}}%
231 \NewDocumentCommand{\hereusederivedunits}{ m }{\begingroup\alwaysusederivedunits#1\endgroup}%
232 \NewDocumentCommand{\hereusealternateunits}{ m }{\begingroup\alwaysusealternateunits#1\endgroup}%
233 \NewDocumentCommand{\hereuseapproximateconstants}{ m }{\hegingroup\alwaysuseapproximateconstants#1\endgroup}\%
234 \NewDocumentCommand{\hereusepreciseconstants}{ m }{\begingroup\alwaysusepreciseconstants#1\endgroup}%
    Document level environments.
235 \NewDocumentEnvironment{usebaseunits}{}{\alwaysusebaseunits}{}%
236 \NewDocumentEnvironment{usederivedunits}{}{\alwaysusederivedunits}{}}
237 \NewDocumentEnvironment{usealternateunits}{}{\alwaysusealternateunits}{}}
```

```
238 \NewDocumentEnvironment{useapproximateconstants}{}{\alwaysuseapproximateconstants}{}\% 239 \NewDocumentEnvironment{usepreciseconstants}{}\%
```

Defining a new scalar quantity. I am very much aware that this family of commands doesn't yet correctly abide by the IATEX3 concept of separating document commands from the programming layer. The problem is that current documentation is not completely understandable to me and getting help is difficult for non-experts.

```
240 \NewDocumentCommand{\newscalarquantity}{ m m O{#2} O{#2} }{%
    \expandafter\newcommand\csname #1value\endcsname[1]{##1}%
243
    \expandafter\newcommand\csname #1baseunits\endcsname[1]{##1\.\mandi@selectbaseunits{#2}{#3}{#4}}%
244
    \expandafter\newcommand\csname #1derivedunits\endcsname[1]{##1\,\mandi@selectderivedunits{#2}{#3}{#4}}%
    \expandafter\newcommand\csname #1alternateunits\endcsname[1]{##1\,\mandi@selectalternateunits{#2}{#3}{#4}}%
245
246
    \expandafter\newcommand\csname #1onlybaseunits\endcsname{\mandi@selectbaseunits{#2}{#3}{#4}}%
247
    \expandafter\newcommand\csname #1onlyderivedunits\endcsname{\mandi@selectderivedunits{#2}{#3}{#4}}%
248
    \expandafter\newcommand\csname #1onlyalternateunits\endcsname{\mandi@selectalternateunits{#2}{#3}{#4}}%
249 }%
```

Redefining a new scalar quantity.

```
250 \NewDocumentCommand{\renewscalarquantity}{ m m O{#2} O{#2} }{%
     \expandafter\renewcommand\csname #1\endcsname[1]{##1\,\mandi@selectunits{#2}{#3}{#4}}%
252
     \expandafter\renewcommand\csname #1value\endcsname[1]{##1}%
253
     \expandafter\renewcommand\csname #1baseunits\endcsname[1]{##1\,\mandi@selectbaseunits{#2}{#3}{#4}}%
254
     \expandafter\renewcommand\csname #1derivedunits\endcsname[1]{##1\,\mandi@selectderivedunits{#2}{#3}{#4}}%
     \expandafter\renewcommand\csname #1alternateunits\endcsname[1]{##1\,\mandi@selectalternateunits{#2}{#3}{#4}}%
255
256
     \expandafter\renewcommand\csname #1onlybaseunits\endcsname{\mandi@selectbaseunits{#2}{#3}{#4}}%
257
     \expandafter\renewcommand\csname #1onlyderivedunits\endcsname{\mandi@selectderivedunits{#2}{#3}{#4}}%
258
     \expandafter\renewcommand\csname #1onlyalternateunits\endcsname{\mandi@selectalternateunits{#2}{#3}{#4}}%
259 }%
```

Defining a new vector quantity. Note that a corresponding scalar is also defined.

```
260 \NewDocumentCommand{\newvectorquantity}{ m m 0{#2} 0{#2} }{%
261 \newscalarquantity{#1}{#2}[#3][#4]
262 \expandafter\newcommand\csname vector#1\endcsname[1]{\expandafter\csname #1\endcsname{\mivector{##1}}}%
263 \expandafter\newcommand\csname #1vector\endcsname[1]{\expandafter\csname #1\endcsname{\mivector{##1}}}%
264 }%
```

Redefining a new vector quantity. Note that a corresponding scalar is also redefined.

```
265 \NewDocumentCommand{\renewvectorquantity}{ m m 0{#2} 0{#2} }{%
266 \renewscalarquantity{#1}{#2}[#3][#4]
267 \expandafter\renewcommand\csname vector#1\endcsname[1]{\expandafter\csname #1\endcsname{\mivector{##1}}}%
268 \expandafter\renewcommand\csname #1vector\endcsname[1]{\expandafter\csname #1\endcsname{\mivector{##1}}}%
269 }%
```

Defining a new physical constant.

```
270 \NewDocumentCommand{\newphysicalconstant}{ m m m m 0{#5} 0{#5} }{%
    \expandafter\newcommand\csname #1\endcsname
271
      {\mandi@selectprecision{#3}{#4}\,\mandi@selectunits{#5}{#6}{#7}}%
272
273
     \expandafter\newcommand\csname #1mathsymbol\endcsname{\ensuremath{#2}}%
     \expandafter\newcommand\csname #1approximatevalue\endcsname{\ensuremath{#3}}%
274
     \expandafter\newcommand\csname #1precisevalue\endcsname{\ensuremath{#4}}%
275
     \expandafter\newcommand\csname #1baseunits\endcsname
276
      277
278
    \expandafter\newcommand\csname #1derivedunits\endcsname
279
      {\mandi@selectprecision{#3}{#4}\,\mandi@selectderivedunits{#5}{#6}{#7}}%
    \expandafter\newcommand\csname #1alternateunits\endcsname
280
      {\mandi@selectprecision{#3}{#4}\,\mandi@selectalternateunits{#5}{#6}{#7}}%
281
    \expandafter\newcommand\csname #1onlybaseunits\endcsname
282
      {\mandi@selectbaseunits{#5}{#6}{#7}}%
283
     \expandafter\newcommand\csname #1onlyderivedunits\endcsname
284
```

```
{\mandi@selectderivedunits{#5}{#6}{#7}}%
285
     \expandafter\newcommand\csname #1onlyalternateunits\endcsname
286
       {\mandi@selectalternateunits{#5}{#6}{#7}}%
287
288 }%
    Redefining a new physical constant.
289 \NewDocumentCommand{\renewphysicalconstant}{ m m m m 0{#5} 0{#5} }{%
     \expandafter\renewcommand\csname #1\endcsname
       {\mandi@selectprecision{#3}{#4}\,\mandi@selectunits{#5}{#6}{#7}}%
291
     \expandafter\renewcommand\csname #1mathsymbol\endcsname{\ensuremath{#2}}%
292
     \expandafter\renewcommand\csname #1approximatevalue\endcsname{\ensuremath{#3}}}%
293
     \expandafter\renewcommand\csname #1precisevalue\endcsname{\ensuremath{#4}}%
294
     \expandafter\renewcommand\csname #1baseunits\endcsname
295
       {\mandi@selectprecision{#3}{#4}\,\mandi@selectbaseunits{#5}{#6}{#7}}%
296
     \expandafter\renewcommand\csname #1derivedunits\endcsname
297
298
       {\mandi@selectprecision{#3}{#4}\,\mandi@selectderivedunits{#5}{#6}{#7}}%
     \expandafter\renewcommand\csname #1alternateunits\endcsname
299
       {\mandi@selectprecision{#3}{#4}\,\mandi@selectalternateunits{#5}{#6}{#7}}%
300
     \expandafter\renewcommand\csname #1onlybaseunits\endcsname
301
       {\mandi@selectbaseunits{#5}{#6}{#7}}%
302
     \expandafter\renewcommand\csname #1onlyderivedunits\endcsname
303
       {\mandi@selectderivedunits{#5}{#6}{#7}}%
304
     \expandafter\renewcommand\csname #1onlyalternateunits\endcsname
305
       {\mandi@selectalternateunits{#5}{#6}{#7}}%
306
307 }%
    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 \stackrel{\rightarrow}{} P. 6, with values true and false, selects precise numerical values for constants rather than approximate
    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.
308 \newif\ifusingpreciseconstants
309 \pgfkeys{%
     /mandi/options/.cd,
310
     initial@setup/.style={%
311
       /mandi/options/buffered@units/.initial=alternate,%
312
     },%
313
314
     initial@setup,%
     preciseconstants/.is if=usingpreciseconstants,%
315
     units/.is choice,%
316
     units/.default=derived,%
317
318
     units/alternate/.style={/mandi/options/buffered@units=alternate},%
     units/base/.style={/mandi/options/buffered@units=base},%
320
     units/derived/.style={/mandi/options/buffered@units=derived},%
321 }%
    Process the options.
322 \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.
323 \newcommand*{\mandi@linetwo}{\typeout{mandi: Loadtime options...}}
324 \newcommand*{\mandi@do@setup}{%
325
     \typeout{}%
     \typeout{mandi: You are using mandi \mandiversion.}%
326
     \mandi@linetwo
327
     \csname alwaysuse\pgfkeysvalueof{/mandi/options/buffered@units}units\endcsname%
328
```

\typeout{mandi: You will get \pgfkeysvalueof{/mandi/options/buffered@units}\space units.}%

329

```
\ifusingpreciseconstants
330
       \alwaysusepreciseconstants
331
       \typeout{mandi: You will get precise constants.}%
332
     \else
333
       \alwaysuseapproximateconstants
334
       \typeout{mandi: You will get approximate constants.}%
335
336
     \fi
     \typeout{}%
337
338 }%
339 \mandi@do@setup
```

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

```
340 \NewDocumentCommand{\mandisetup}{ m }{%

341 \IfValueT{#1}{%

342 \pgfqkeys{/mandi/options}{#1}

343 \renewcommand*{\mandi@linetwo}{\typeout{mandi: mandisetup options...}}

344 \mandi@do@setup

345 }%

346 }%
```

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.

```
347 \newvectorquantity{acceleration}%
     {\meter\usk\second\totheinversetwo}%
349
     [\newton\per\kilogram]%
     [\meter\per\second\tothetwo]%
351 \newscalarquantity{amount}%
     {\mole}%
353 \newvectorquantity{angularacceleration}%
     {\radian\usk\second\totheinversetwo}%
     [\radian\per\second\tothetwo]%
     [\radian\per\second\tothetwo]%
357 \newscalarquantity{angularfrequency}%
     {\radian\usk\second\inverse}%
358
     [\radian\per\second]%
359
     [\radian\per\second]%
360
361 %\ifmandi@rotradians
     \newphysicalquantity{angularimpulse}%
363 %
        {\meter\tothetwo\usk\kilogram\usk\second\inverse\usk\radian\inverse}%
        [\joule\usk\second\per\radian]%
364 %
        [\newton\usk\meter\usk\second\per\radian]%
365 %
      \newphysicalquantity{angularmomentum}%
366 %
        {\meter\tothetwo\usk\kilogram\usk\second\inverse\usk\radian\inverse}%
367 %
        [\kilogram\usk\meter\tothetwo\per(\second\usk\radian)]%
368 %
        [\newton\usk\meter\usk\second\per\radian]%
369 %
370 %\else
     \newvectorquantity{angularimpulse}%
371
       {\meter\tothetwo\usk\kilogram\usk\second\inverse}%
372
       [\kilogram\usk\meter\tothetwo\per\second]% % also \joule\usk\second
373
       [\kilogram\usk\meter\tothetwo\per\second] % % also \newton\usk\meter\usk\second
374
     \newvectorquantity{angularmomentum}%
375
376
       {\meter\tothetwo\usk\kilogram\usk\second\inverse}%
       [\kilogram\usk\meter\tothetwo\per\second]% % also \joule\usk\second
377
       [\kilogram\usk\meter\tothetwo\per\second] % % also \newton\usk\meter\usk\second
378
379 %\fi
380 \newvectorquantity{angularvelocity}%
     {\radian\usk\second\inverse}%
```

```
[\radian\per\second]%
382
     [\radian\per\second]%
383
384 \newscalarquantity{area}%
     {\meter\tothetwo}%
386 \newscalarquantity{areamassdensity}%
     {\meter\totheinversetwo\usk\kilogram}%
388
     [\kilogram\per\meter\tothetwo]%
389
     [\kilogram\per\meter\tothetwo]%
390 \newscalarquantity{areachargedensity}%
     {\meter\totheinversetwo\usk\second\usk\ampere}%
     [\coulomb\per\meter\tothetwo]%
392
393
     [\coulomb\per\meter\tothetwo]%
394 \newscalarquantity{capacitance}%
     {\meter\totheinversetwo\usk\kilogram\inverse\usk\second\tothefour\usk\ampere\tothetwo}%
     [\farad]%
396
     [\coulomb\per\volt]% % also \coulomb\tothetwo\per\newton\usk\meter, \second\per\ohm
397
398 \newscalar
quantity{charge}%
     {\ampere\usk\second}%
     [\coulomb]%
400
     [\coulomb]% % also \farad\usk\volt
402 \newvectorquantity{cmagneticfield}%
     {\meter\usk\kilogram\usk\second\totheinversethree\usk\ampere\inverse}%
403
     [\volt\per\meter]%
404
     [\newton\per\coulomb]%
405
406 \newscalarquantity{conductance}%
     {\meter\totheinversetwo\usk\kilogram\inverse\usk\second\tothethree\usk\ampere\tothetwo}%
407
     [\siemens]%
408
     [\ampere\per\volt]%
409
410 \newscalarquantity{conductivity}%
411
     {\meter\totheinversethree\usk\kilogram\inverse\usk\second\tothethree\usk\ampere\tothetwo}%
     [\siemens\per\meter]%
412
     [(\ampere\per\meter\tothetwo)\per(\volt\per\meter)]%
414 \newscalarquantity{conventionalcurrent}%
415
     {\ampere}%
     [\coulomb\per\second]%
416
     [\ampere]%
417
418 \newscalarquantity{current}%
     {\ampere}%
420 \newscalarquantity{currentdensity}%
     {\meter\totheinversetwo\usk\ampere}%
422
     [\coulomb\usk\second\per\meter\tothetwo]%
     [\ampere\per\meter\tothetwo]%
423
424 \newscalarquantity{dielectricconstant}%
     {}%
425
426 \newvectorquantity{displacement}%
     {\meter}
428 \newscalarquantity{duration}%
     {\second}%
430 \newvectorquantity{electricdipolemoment}%
     {\meter\usk\second\usk\ampere}%
431
     [\coulomb\usk\meter]%
432
     [\coulomb\usk\meter]%
433
434 \newvectorquantity{electricfield}%
     {\meter\usk\kilogram\usk\second\totheinversethree\usk\ampere\inverse}%
435
     [\volt\per\meter]%
436
     [\newton\per\coulomb]%
437
438 \newscalarquantity{electricflux}%
     {\meter\tothethree\usk\kilogram\usk\second\totheinversethree\usk\ampere\inverse}%
440
     [\volt\usk\meter]%
```

```
[\newton\usk\meter\tothetwo\per\coulomb]%
441
442 \newscalarquantity{electricpotential}%
     {\meter\tothetwo\usk\kilogram\usk\second\totheinversethree\usk\ampere\inverse}}
443
     [\volt]%
444
     [\joule\per\coulomb]%
445
446 \newscalarquantity{electroncurrent}%
     {\second\inverse}%
     [\ensuremath{\symup{e}}\per\second]%
448
     [\ensuremath{\symup{e}}\per\second]%
449
450 \newscalarquantity{emf}%
     {\meter\tothetwo\usk\kilogram\usk\second\totheinversethree\usk\ampere\inverse}%
451
452
     [\volt]%
     [\joule\per\coulomb]%
454 \newscalarquantity{energy}%
     {\meter\tothetwo\usk\kilogram\usk\second\totheinversetwo}%
455
     [\joule]% % also \newton\usk\meter
456
     [\joule]%
457
458 \newscalarquantity{energydensity}%
     {\meter\inverse\usk\kilogram\usk\second\totheinversetwo}%
459
460
     [\joule\per\meter\tothethree]%
     [\joule\per\meter\tothethree]%
461
462 \newscalarquantity{energyflux}%
     {\kilogram\usk\second\totheinversethree}%
463
     [\watt\per\meter\tothetwo]%
464
     [\watt\per\meter\tothetwo]%
465
466 \newscalarquantity{entropy}%
     {\meter\tothetwo\usk\kilogram\usk\second\totheinversetwo\usk\kelvin\inverse}%
467
     [\joule\per\kelvin]%
468
     [\joule\per\kelvin]%
469
470 \newvectorquantity{force}%
     {\meter\usk\kilogram\usk\second\totheinversetwo}%
471
472
     [\newton]% % also \kilogram\usk\meter\per\second\tothetwo
474 \newscalarquantity{frequency}%
     {\second\inverse}%
475
     [\hertz]%
476
     [\hertz]%
477
478 \newvectorquantity{gravitationalfield}%
     {\meter\usk\second\totheinversetwo}%
     [\newton\per\kilogram]%
480
     [\newton\per\kilogram]%
481
482 \newscalarquantity{gravitationalpotential}%
     {\meter\tothetwo\usk\second\totheinversetwo}%
483
     [\joule\per\kilogram]%
484
     [\joule\per\kilogram]%
485
486 \newvectorquantity{impulse}%
     {\meter\usk\kilogram\usk\second\inverse}%
487
     [\newton\usk\second]%
488
     [\newton\usk\second]%
489
490 \newscalarquantity{indexofrefraction}%
492 \newscalarquantity{inductance}%
     {\meter\tothetwo\usk\kilogram\usk\second\totheinversetwo\usk\ampere\totheinversetwo}%
493
494
     [\henry]%
     [\volt\usk\second\per\ampere]% % also \square\meter\usk\kilogram\per\coulomb\tothetwo, \Wb\per\ampere
495
496 \newscalarquantity{linearchargedensity}%
     {\meter\inverse\usk\second\usk\ampere}%
497
498
     [\coulomb\per\meter]%
     [\coulomb\per\meter]%
```

```
500 \newscalarquantity{linearmassdensity}%
          {\meter\inverse\usk\kilogram}%
501
           [\kilogram\per\meter]%
502
          [\kilogram\per\meter]%
503
504 \newscalarquantity{luminous}%
          {\candela}%
506 \newscalarquantity{magneticcharge}%
          {\meter\usk\ampere}%
508 \newvectorquantity{magneticdipolemoment}%
          {\meter\tothetwo\usk\ampere}%
          [\ampere\usk\meter\tothetwo]%
510
511
          [\joule\per\tesla]%
512 \newvectorquantity{magneticfield}%
          {\kilogram\usk\second\totheinversetwo\usk\ampere\inverse}%
          [\tesla]%
514
          [\newton\per\coulomb\usk(\meter\per\second)]% % also \Wb\per\meter\tothetwo
515
516 \newscalarquantity{magneticflux}%
          {\meter\tothetwo\usk\kilogram\usk\second\totheinversetwo\usk\ampere\inverse}%
          [\tesla\usk\meter\tothetwo]%
          [\volt\usk\second]% % also \Wb and \joule\per\ampere
520 \newscalarquantity{mass}%
          {\kilogram}%
522 \newscalarquantity{mobility}%
          {\meter\tothetwo\usk\kilogram\usk\second\totheinversefour\usk\ampere\inverse}%
523
          [\meter\tothetwo\per\volt\usk\second]%
524
           [(\meter\per\second)\per(\newton\per\coulomb)]%
525
526 \newscalarquantity{momentofinertia}%
527
          {\meter\tothetwo\usk\kilogram}%
          [\joule\usk\second\tothetwo]%
528
          [\kilogram\usk\meter\tothetwo]%
529
530 \newvectorquantity{momentum}%
          {\meter\usk\kilogram\usk\second\inverse}%
532
          [\newton\usk\second]%
          [\kilogram\usk\meter\per\second]%
534 \newvectorquantity{momentumflux}%
          {\meter\inverse\usk\kilogram\usk\second\totheinversetwo}%
535
          [\newton\per\meter\tothetwo]%
536
537
          [\newton\per\meter\tothetwo]%
538 \newscalarquantity{numberdensity}%
          {\meter\totheinversethree}%
          [\per\meter\tothethree]%
540
          [\per\meter\tothethree]%
542 \newscalarquantity{permeability}%
          {\mbox{\tt \wall} we kilogram \verb|\usk| second \verb|\tothe inverse two| usk \verb|\ampere| to the inverse two} % $$ $ \mbox{\tt \wall} $$ $ \mbox{\tt \usk} $$ $\mbox{\tt \usk} $$ $ \mbox{\tt \usk} $$ \mbox{\tt \usk} $$ $ \mbox{\tt \usk} $$ $ \mbox{\tt \usk} $$ $ \
543
544
          [\tesla\usk\meter\per\ampere]%
          [\henry\per\meter]%
546 \newscalarquantity{permittivity}%
          {\meter\totheinversethree\usk\kilogram\inverse\usk\second\totheinversefour\usk\ampere\tothetwo}%
547
          [\farad\per\meter]%
548
           [\coulomb\tothetwo\per\newton\usk\meter\tothetwo]%
549
550 \newscalarquantity{planeangle}%
          {\meter\usk\meter\inverse}%
551
          [\radian]%
552
          [\radian]%
553
554 \newscalarquantity{polarizability}%
          {\kilogram\inverse\usk\second\tothefour\usk\ampere\tothetwo}%
555
          [\coulomb\usk\meter\tothetwo\per\volt]%
556
557
          [\coulomb\usk\meter\per(\newton\per\coulomb)]%
558 \newscalarquantity{power}%
```

```
{\meter\tothetwo\usk\kilogram\usk\second\totheinversethree}%
559
     [\watt]%
560
     [\joule\per\second]%
561
562 \newvector quantity{poynting}\%
     {\kilogram\usk\second\totheinversethree}%
563
     [\watt\per\meter\tothetwo]%
564
565
     [\watt\per\meter\tothetwo]%
566 \newscalarquantity{pressure}%
     {\meter\inverse\usk\kilogram\usk\second\totheinversetwo}%
567
     [\pascal]%
568
     [\newton\per\meter\tothetwo]%
569
570 \newscalarquantity{relativepermeability}
572 \newscalarquantity{relativepermittivity}%
573
574 \newscalarquantity{resistance}%
     {\cond\totheinversethree\usk\ampere\totheinversetwo}\% and the inverse three \usk\ampere\totheinversetwo}\% and the inverse three \usk\ampere\totheinversetwo.
575
     [\volt\per\ampere]%
576
     [\ohm]%
578 \newscalarquantity{resistivity}%
579
     {\meter\tothethree\usk\kilogram\usk\second\totheinversethree\usk\ampere\totheinversetwo}%
     [\ohm\usk\meter]%
580
     [(\volt\per\meter)\per(\ampere\per\meter\tothetwo)]%
581
582 \newscalarquantity{solidangle}%
     {\meter\tothetwo\usk\meter\totheinversetwo}%
583
     [\steradian]%
     [\steradian]%
585
586 \newscalarquantity{specificheatcapacity}%
     {\meter\tothetwo\usk\second\totheinversetwo\usk\kelvin\inverse}%
587
     [\joule\per\kelvin\usk\kilogram]%
588
     [\joule\per\kelvin\usk\kilogram]
589
590 \newscalarquantity{springstiffness}%
     {\kilogram\usk\second\totheinversetwo}%
     [\newton\per\meter]%
592
     [\newton\per\meter]%
593
594 \newscalarquantity{springstretch}% % This is really just a displacement.
     {\meter}%
596 \newscalarquantity{stress}%
     {\meter\inverse\usk\kilogram\usk\second\totheinversetwo}%
     [\pascal]%
     [\newton\per\meter\tothetwo]%
599
600 \newscalarquantity{strain}%
     {}%
601
602 \newscalarquantity{temperature}%
    {\left\{ \ kelvin \right\} \%}
604 %\ifmandi@rotradians
605 % \newphysicalquantity{torque}%
         {\meter\tothetwo\usk\kilogram\usk\second\totheinversetwo\usk\radian\inverse}%
606 %
607 %
         [\newton\usk\meter\per\radian]%
         [\newton\usk\meter\per\radian]%
608 %
609 %\else
     \newvectorquantity{torque}%
       {\meter\tothetwo\usk\kilogram\usk\second\totheinversetwo}%
611
        [\newton\usk\meter]%
612
        [\newton\usk\meter]%
613
614 %\fi
615 \newvectorquantity{velocity}%
616
     {\meter\usk\second\inverse}%
617
     [\meter\per\second]%
```

```
[\meter\per\second]%
618
619 \newvectorquantity{velocityc}%
    {\lightspeed}%
620
     []%
621
    [\lightspeed]%
622
623 \newscalarquantity{volume}%
    {\meter\tothethree}%
625 \newscalarquantity{volumechargedensity}%
    {\meter\totheinversethree\usk\second\usk\ampere}%
626
     [\coulomb\per\meter\tothethree]%
627
     [\coulomb\per\meter\tothethree]%
628
629 \newscalarquantity{volumemassdensity}%
    {\meter\totheinversethree\usk\kilogram}%
     [\kilogram\per\meter\tothethree]%
     [\kilogram\per\meter\tothethree]%
632
633 \newscalarquantity{wavelength}% % This is really just a displacement.
    {\meter}%
635 \newvectorquantity{wavenumber}%
    {\meter\inverse}%
     [\per\meter]%
     [\per\meter]%
639 \newscalarquantity{work}%
    {\meter\tothetwo\usk\kilogram\usk\second\totheinversetwo}%
640
     [\joule]%
641
642
     [\newton\usk\meter]%
643 \newscalarquantity{youngsmodulus}% % This is really just a stress.
    {\meter\inverse\usk\kilogram\usk\second\totheinversetwo}%
645
     [\pascal]%
    [\newton\per\meter\tothetwo]%
646
   Define physical constants for introductory physics, again alphabetically for convenience.
647 \newphysicalconstant{avogadro}%
    {\sup\{N_A}}
    {6\timestento{23}}{6.02214076\timestento{23}}%
650
    {\mole\inverse}%
     [\per\mole]%
651
     [\per\mole]%
652
653 \newphysicalconstant{biotsavartconstant}% % alias for \mzofp
    {\sup{\frac{\mu_o}{4\pi c}}}
    {\left(-7\right)}{\left(-7\right)}
    {\meter\usk\kilogram\usk\second\totheinversetwo\usk\ampere\totheinversetwo}%
656
     [\henry\per\meter]%
657
     [\tesla\usk\meter\per\ampere]%
658
659 \newphysicalconstant{bohrradius}%
660
    {\symup{a_o}}%
661
    \{5.3\timestento\{-11\}\}\{5.2917721067\timestento\{-11\}\}\%
    {\meter}%
663 \newphysicalconstant{boltzmann}%
    {\sup\{k_B}}%
664
    {1.4\times -23}}{1.380649\times -23}}%
665
    {\meter\tothetwo\usk\kilogram\usk\second\totheinversetwo\usk\kelvin\inverse}%
666
667
     [\joule\per\kelvin]%
     [\joule\per\kelvin]%
669 \newphysicalconstant{coulombconstant}% % alias for \oofpez
    {\symup{\frac{1}{4\pi\epsilon_o}}}%
670
    {9\times 517873681764\times 69}
671
672
    673
    [\meter\per\farad]%
674
     [\newton\usk\meter\tothetwo\per\coulomb\tothetwo]%
```

```
675 \newphysicalconstant{earthmass}%
           {\symup{M_{Earth}}}%
676
           \{6.0 \times \{24\}\} \{5.97237 \times \{24\}\} \%
677
           {\kilogram}%
678
679 \newphysicalconstant{earthmoondistance}%
           {\symup{d_{EM}}}%
           {3.8\times \{3.8\times \{3.81550\times \{8\}\}\}}
         {\meter}%
682
683 \newphysicalconstant{earthradius}%
           {\symup{R_{Earth}}}%
           \{6.4 \times \{6.4 \times \{6.371 \times \{6.371 \times \{6.4\}\}\}\}
685
686
           {\meter}%
687 \newphysicalconstant{earthsundistance}%
           {\symup{d_{ES}}}%
           \{1.5\timestento\{11\}\}\{1.496\timestento\{11\}\}\%
689
           {\meter}%
690
691 \newphysicalconstant{electroncharge}%
           {\symup{q_e}}%
692
           {-\elementarychargeapproximatevalue}{-\elementarychargeprecisevalue}%
           {\ampere\usk\second}%
           [\coulomb]%
695
            [\coulomb]%
696
697 \newphysicalconstant{electronCharge}%
           {\sup{Q_e}}%
698
            \verb| \{-\end{tabular} $$ \{-\end{
699
           {\ampere\usk\second}%
700
            [\coulomb]%
701
            [\coulomb]%
702
703 \newphysicalconstant{electronmass}%
704
           {\sup\{m_e\}}%
           {9.1\times -31}
705
           {\kilogram}%
707 \newphysicalconstant{elementarycharge}%
           {\symup{e}}%
           \{1.6\timestento\{-19\}\}\{1.602176634\timestento\{-19\}\}\%
709
           {\ampere\usk\second}%
710
            [\coulomb]%
711
            [\coulomb]%
712
713 \newphysicalconstant{finestructure}%
           {\symup{\alpha}}%
           {\frac{1}{137}}{7.2973525664\times{-3}}%
715
716
717 \newphysicalconstant{hydrogenmass}%
           {\sup_{m_H}}%
718
           {1.7}\times{-27}{1.6737236}\times{-27}}%
719
           {\kilogram}%
721 \newphysicalconstant{moonearthdistance}%
           {\sup\{d_{ME}\}}%
           {3.8\times 1550\times 8}
723
           {\meter}%
724
725 \newphysicalconstant{moonmass}%
           {\sup\{M_{Moon}\}}
726
           {7.3\times \{7.3\times \{22\}\}}{7.342\times \{22\}}%
727
           {\kilogram}%
729 \newphysicalconstant{moonradius}%
730
           {\symup{R_{Moon}}}%
           \{1.7\timestento\{6\}\}\{1.7371\timestento\{6\}\}\%
731
732
           {\meter}%
733 \newphysicalconstant{mzofp}%
```

```
{\sup{\frac{\mu_o}{4\pi^2}}}
734
     {\tento{-7}}{\tento{-7}}%
735
     {\meter\usk\kilogram\usk\second\totheinversetwo\usk\ampere\totheinversetwo}%
736
     [\henry\per\meter]%
737
     [\tesla\usk\meter\per\ampere]%
738
739 \newphysicalconstant{neutronmass}%
     {\sup\{m_n}}
     \{1.7 \times (-27)\} \{1.674927471 \times (-27)\} \%
741
    {\kilogram}%
742
743 \newphysicalconstant{oofpez}%
     {\symup{\frac{1}{4\pi\epsilon_o}}}%
     {9\timestento{9}}{8.987551787\timestento{9}}%
745
     {\meter\tothethree\usk\kilogram\usk\second\totheinversefour\usk\ampere\totheinversetwo}%
746
     [\meter\per\farad]%
     [\newton\usk\meter\tothetwo\per\coulomb\tothetwo]%
748
749 \newphysicalconstant{oofpezcs}%
     {\symup{\frac{1}{4\pi\epsilon_o c^2}}}%
750
     {\tento{-7}}{\tento{-7}}%
751
     {\meter\usk\kilogram\usk\second\totheinversetwo\usk\ampere\totheinversetwo}%
753
     [\tesla\usk\meter\tothetwo]%
     [\newton\usk\second\tothetwo\per\coulomb\tothetwo]%
754
755 \newphysicalconstant{planck}%
     {\sup\{h}}%
756
     \{6.6\timestento\{-34\}\}\{6.62607015\timestento\{-34\}\}\%
757
     {\meter\tothetwo\usk\kilogram\usk\second\inverse}%
758
759
     [\joule\usk\second]%
     [\joule\usk\second]%
760
    See https://tex.stackexchange.com/a/448565/218142.
761 \newphysicalconstant{planckbar}%
     {\symup{\lower0.18ex\hbox{\mathchar"AF}\mkern-7mu h}}%
762
     {1.1\times -34}{1.054571817\times -34}%
763
764
    {\meter\tothetwo\usk\kilogram\usk\second\inverse}%
     [\joule\usk\second]%
765
     [\joule\usk\second]
766
767 \newphysicalconstant{planckc}%
    {\symup{hc}}%
768
     {2.0\times {-25}}{1.98644586\times {-25}}%
769
770
     {\meter\tothethree\usk\kilogram\usk\second\totheinversetwo}%
     [\joule\usk\meter]%
771
     [\joule\usk\meter]%
772
773 \newphysicalconstant{protoncharge}%
     {\sup\{q_p\}}%
775
     {+\elementarychargeapproximatevalue}{+\elementarychargeprecisevalue}%
776
     {\ampere\usk\second}%
777
     [\coulomb]%
     [\coulomb]%
778
779 \newphysicalconstant{protonCharge}%
     {\sup{Q_p}}%
780
     {+\elementarychargeapproximatevalue}{+\elementarychargeprecisevalue}%
781
     {\ampere\usk\second}%
782
     [\coulomb]%
783
     [\coulomb]%
785 \newphysicalconstant{protonmass}%
786
     {\sup\{m_p}}%
     {1.7\times -27}{1.672621898\times -27}%
787
     {\kilogram}%
788
789 \newphysicalconstant{rydberg}%
     {\sup{R_{\min{ty}}}}
```

```
{1.1\timestento{7}}{1.0973731568508\timestento{7}}%
791
     {\meter\inverse}%
792
793 \newphysicalconstant{speedoflight}%
     {\symup{c}}%
794
     {3\timestento{8}}{2.99792458\timestento{8}}%
795
     {\meter\usk\second\inverse}%
796
797
     [\meter\per\second]%
798
     [\meter\per\second]
799 \newphysicalconstant{stefanboltzmann}%
     {\symup{\sigma}}%
800
     \{5.7\timestento\{-8\}\}\{5.670367\timestento\{-8\}\}\%
801
     {\kilogram\usk\second\totheinversethree\usk\kelvin\totheinversefour}%
802
     [\watt\per\meter\tothetwo\usk\kelvin\tothefour]%
803
     [\watt\per\meter\tothetwo\usk\kelvin\tothefour]
804
805 \newphysicalconstant{sunearthdistance}%
     {\symup{d {SE}}}%
806
     \{1.5\timestento\{11\}\}\{1.496\timestento\{11\}\}\%
807
     {\meter}%
808
809 \newphysicalconstant{sunmass}%
     {\sup\{M_{Sun}\}}
     {2.0}\timestento{30}{1.98855}\timestento{30}}\%
811
     {\kilogram}%
812
813 \newphysicalconstant{sunradius}%
     {\sup{R_{Sun}}}
814
     \{7.0 \neq 8\} 
815
817 \newphysicalconstant{surfacegravfield}%
     {\symup{g}}%
818
     {9.8}{9.807}%
819
     {\meter\usk\second\totheinversetwo}%
820
     [\newton\per\kilogram]%
821
     [\newton\per\kilogram]%
823 \newphysicalconstant{universalgrav}%
824
     {\sup\{G}}%
     \{6.7\timestento\{-11\}\}\{6.67408\timestento\{-11\}\}\%
825
     {\tt \{\mbox{\tt weter} to the three \mbox{\tt kilogram} inverse \mbox{\tt usk} second \mbox{\tt to the inverse two}}\%
826
     [\newton\usk\meter\tothetwo\per\kilogram\tothetwo]% % also \joule\usk\meter\per\kilogram\tothetwo
827
     [\newton\usk\meter\tothetwo\per\kilogram\tothetwo]%
829 \newphysicalconstant{vacuumpermeability}%
     {\symup{\mu_o}}%
830
     {4\neq -7}}{4\neq -7}}{4\neq -7}}%
831
     {\meter\usk\kilogram\usk\second\totheinversetwo\usk\ampere\totheinversetwo}%
832
     [\henry\per\meter]%
833
     [\tesla\usk\meter\per\ampere]%
834
835 \newphysicalconstant{vacuumpermittivity}%
836
     {\symup{\epsilon_o}}%
     {9 \times {-12}}{8.854187817 \times {-12}}%
837
     {\meter\totheinversethree\usk\kilogram\inverse\usk\second\tothefour\usk\ampere\tothetwo}%
838
839
     [\farad\per\meter]%
     [\coulomb\tothetwo\per\newton\usk\meter\tothetwo]%
840
    A better, intelligent coordinate-free \vec<sup>→P.35</sup> 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 TFX 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.
```

841 \RenewDocumentCommand{\vec}{ s m e{ $_{^{}}$ } }{%

842

\ensuremath{%

```
% Note the \, used to make superscript look better.
843
       \IfBooleanTF {#1}
844
         {\vv{#2}%
                         % * gives an arrow
845
            % Use sp{} primitive for superscript.
846
            % Adjust superscript for the arrow.
847
            \fill T{\#4}{\,\#4}\vphantom{\smash[t]{\big|}}}
848
849
         }%
         {\symbfit{#2} % no * gives us bold
850
            % Use sp{} primitive for superscript.
851
            % No superscript adjustment needed.
852
            \sp{\IfValueT{#4}{#4}\vphantom{\smash[t]{\big|}}}
853
         }%
854
       % Use \sb{} primitive for subscript.
855
       \sh\{\IfValueT\{\#3\}\{\#3\}\vphantom\{\smash[b]\{\}\}\}\
856
     }%
857
858 }%
    A command for the direction of a vector. We use a slight tweak is needed to get uniform hats that requires the makebox
See https://tex.stackexchange.com/a/391204/218142.
859 \NewDocumentCommand{\dirvec}{ s m e{_{^{}}} }{%
     \ensuremath{%
       \widetilde{\} \
861
862
         \IfBooleanTF {#1}
863
           {%
             #2
864
           }%
865
866
           {%
              \symbfit{#2}
867
           }%
868
          }%
869
         }%
870
        }%
871
       \st {\If ValueT{#3}{#3}\vphantom{\smash[b]{|}}}
872
       \sp{\If ValueT{#4}{\,#4}\vphantom{\smash[t]{\big|}}}
873
874
     }%
875 }%
    The zero vector.
876 \NewDocumentCommand{\zerovec}{ s }{%
     \IfBooleanTF {#1}
877
       {\vv{0}}%
878
       {\symbfup{0}}%
879
880 }%
    Notation for column and row vectors. \mivector→P.36 is a workhorse command.
 Orginal code provided by @egreg.
 See https://tex.stackexchange.com/a/39054/218142.
881 \ExplSyntaxOn
882 \NewDocumentCommand{\mivector}{ O{,} m o }%
883 {%
      \mi_vector:nn { #1 } { #2 }
884
885
      \If Value T {#3}{\; {#3}}
886 }%
887 \seq new:N \l mi list seq
888 \cs_new_protected:Npn \mi_vector:nn #1 #2
889 {%
     \ensuremath{%
890
```

\seq_set_split:Nnn \l_mi_list_seq { , } { #2 }

891

```
\int_compare:nF { \seq_count:N \l__mi_list_seq = 1 } { \left\langle }
892
       \seq_use:Nnnn \l__mi_list_seq { #1 } { #1 } { #1 }
893
       \int_compare:nF { \seq_count:N \l__mi_list_seq = 1 } { \right\rangle }
894
     }%
895
896 }%
897 \NewDocumentCommand{\colvec}{ O{,} m }{%
898
     \vector_main:nnnn { p } { \\ } { #1 } { #2 }
899 }%
900 \NewDocumentCommand{\rowvec}{ O{,} m }{%
     \vector_main:nnnn { p } { & } { #1 } { #2 }
902 }%
903 \seq_new:N \l__vector_arg_seq
904 \cs_new_protected:Npn \vector_main:nnnn #1 #2 #3 #4 {%
     \seq_set_split:Nnn \l__vector_arg_seq { #3 } { #4 }
     \begin{#1NiceMatrix}[r]
906
       \seq_use:Nnnn \l__vector_arg_seq { #2 } { #2 } { #2 }
907
     \end{#1NiceMatrix}
908
909 }%
910 \ExplSyntaxOff
```

911 $\label{lem:newDocumentCommand} $$911 \end{$\mathbb{T}_{\colored}(\colored)$} $$$

Intelligent delimiters provided via the mathtools package. Use the starred variants for fractions. You can supply optional sizes. Note that default placeholders are used when the argument is empty.

```
912 \DeclarePairedDelimiterX{\doublebars}[1]{\lVert}{\rVert}{\ifblank{#1}{\:\cdot\:}{#1}}
913 \DeclarePairedDelimiterX{\singlebars}[1]{\lvert}{\rvert}{\ifblank{#1}{\:\cdot\:}{#1}}
914 \DeclarePairedDelimiterX{\anglebrackets}[1]{\langle}{\rangle}{\ifblank{#1}{\:\cdot\:}{#1}}
915 \DeclarePairedDelimiterX{\parentheses}[1]{\lfloort}{\ifblank{#1}{\:\cdot\:}{#1}}
916 \DeclarePairedDelimiterX{\squarebrackets}[1]{\lbrack}{\rbrack}{\ifblank{#1}{\:\cdot\:}{#1}}
917 \DeclarePairedDelimiterX{\curlybraces}[1]{\lbrace}{\rbrace}{\ifblank{#1}{\:\cdot\:}{#1}}
```

Some semantic aliases. Because of the way $\ensuremath{\backslash \text{vec}}^{\to P.35}$ and $\ensuremath{\backslash \text{dirvec}}^{\to P.35}$ are defined, I reluctantly decided not to implement a $\ensuremath{\backslash \text{magnet}}$ command. It would require accounting for too mamy options. So $\ensuremath{\backslash \text{magnitude}}^{\to P.38}$ is the new solution.

```
918 \NewDocumentCommand{\magnitude}{}{\doublebars}
919 \NewDocumentCommand{\norm}{}{\doublebars}
920 \NewDocumentCommand{\absolutevalue}{}{\singlebars}
921 \NewDocumentCommand{\direction}{}{\mivector}
922 \NewDocumentCommand{\unitvector}{}{\mivector}
```

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.

```
923 \NewDocumentCommand{\veccomp}{ s m }{%
     \% Consider renaming this to \ensuremath{\texttt{\sc Vectorsym}} .
924
      \IfBooleanTF{#1}
925
926
      {%
927
        \ensuremath{\symnormal{#2}}%
     }%
928
     {%
929
930
        \ensuremath{\symbfit{#2}}%
931
     }%
932 }%
933 \NewDocumentCommand{\tencomp}{ s m }{%
     % Consider renaming this to \tensororsym.
     \IfBooleanTF{#1}
935
936
        \ensuremath{\symsfit{#2}}%
937
938
     }%
     {%
939
```

```
\ensuremath{\symbfsfit{#2}}%
940
941
     }%
942 }%
    An environment for problem statements. The starred variant gives in-line lists.
943 \NewDocumentEnvironment{physicsproblem}{ m }{%
     \newpage%
     \section*{#1}%
945
     \newlist{parts}{enumerate}{2}%
946
     \setlist[parts]{label=\bfseries(\alph*)}}%
947
948
949 \NewDocumentEnvironment{physicsproblem*}{ m }{%
     \newpage%
950
     \section*{#1}%
951
     \newlist{parts}{enumerate*}{2}%
952
     \setlist[parts]{label=\bfseries(\alph*)}}%
953
954
955 \NewDocumentCommand{\problempart}{}{\item}%
    An environment for problem solutions.
956 \NewDocumentEnvironment{physicssolution}{ +b }{%
     % Make equation numbering consecutive through the document.
957
     \begin{align}
958
       #1
959
     \end{align}
960
961 }{}%
962 \NewDocumentEnvironment{physicssolution*}{ +b }{%
     % Make equation numbering consecutive through the document.
963
     \begin{align*}
964
       #1
965
     \end{align*}
966
967 }{}%
    A simplified command for importing images.
968 \NewDocumentCommand{\image}{ O{scale=1} m m m }{%
     \begin{figure}[ht!]
969
       \begin{center}%
970
         \includegraphics[#1]{#2}%
971
972
       \end{center}%
       \caption{#3}%
973
       \label{#4}%
974
     \end{figure}%
975
976 }%
    See https://tex.stackexchange.com/q/570223/218142.
977 \NewDocumentCommand{\reason}{ O{4cm} m }
     Commands for scientific notation.
979 \NewDocumentCommand{\tento}{ m }{\currenath{10^{#1}}}
980 \NewDocumentCommand{\timestento}{ m }{\ensuremath{\;\times\;\tento{#1}}}
981 \NewDocumentCommand{\xtento}{ m }{\ensuremath{\; \times\; \tento{#1}}}
    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.
 982 \newcounter{tikzhighlightnode}
983 \NewDocumentCommand{\hilite}{ O{magenta!60} m O{rectangle} }{%
      \stepcounter{tikzhighlightnode}%
985
      \tikzmarknode{highlighted-node-\number\value{tikzhighlightnode}}{#2}%
      \edef\temp{%
986
        \noexpand\AddToShipoutPictureBG{%
987
          \noexpand\begin{tikzpicture}[overlay,remember picture]%
988
          \noexpand\iftikzmarkoncurrentpage{highlighted-node-\number\value{tikzhighlightnode}}}
989
           \noexpand\node[inner sep=1.0pt,fill=#1,#3,fit=(highlighted-node-\number\value{tikzhighlightnode})]{};%
990
          \noexpand\fi
991
          \noexpand\end{tikzpicture}%
992
        }%
993
994
      }%
 995
      \temp%
996 }%
     Intelligent slot command for coordinate-free tensor notation.
997 \NewDocumentCommand{\slot}{ s d[] }{%
      \% d[] must be used because of the way consecutive optional
      % arguments are handled. See xparse docs for details.
      \IfBooleanTF{#1}
1000
      {%
1001
        \IfValueTF{#2}
1002
        {% Insert a vector, but don't show the slot.
1003
          \smash{\makebox[1.5em]{\ensuremath{#2}}}
1004
1005
        {% No vector, no slot.
1006
          \smash{\makebox[1.5em]{\ensuremath{}}}
1007
        }%
1008
1009
      }%
1010
1011
        \IfValueTF{#2}
1012
        {% Insert a vector and show the slot.
          \underline{\smash{\makebox[1.5em]{\ensuremath{#2}}}}
1013
        ጉ%
1014
        {% No vector; just show the slot.
1015
          \underline{\smash{\makebox[1.5em]{\ensuremath{}}}}
1016
1017
     }%
1018
1019 }%
     Intelligent notation for contraction on pairs of slots.
1020 \NewDocumentCommand{\contraction}{ s m }{%
      \IfBooleanTF{#1}
1021
      {\mathsf{C}}%
1022
      {\symbb{C}}%
1023
1024
     _{#2}
1025 }%
     Intelligent differential (exterior derivative) operator.
1026 \NewDocumentCommand{\dd}{ s }{%
      \mathop{}\!
1027
      \IfBooleanTF{#1}
1028
      {\symbfsfup{d}}%
1029
      {\symsfup{d}}%
1030
```

1031 }%

Command to typeset tensor valence.

```
1032 \NewDocumentCommand{\valence}{ s m m }{%

1033 \IfBooleanTF{#1}

1034 {(#2,#3)}

1035 {\binom{#2}{#3}}

1036 }%
```

Diagnostic commands to provide sanity checks on commands that represent physical quantities and constants.

```
1037 \NewDocumentCommand{\checkquantity}{ m }{%
1038
     % Works for both scalar and vector quantities.
      \begin{center}
1039
        \begin{tabular}{>{\centering}p{4cm} >{\centering}p{3cm} >{\centering}p{4cm} >{\centering}p{3cm}}
1040
          name & base & derived & alternate \tabularnewline
1041
1042
          \ttfamily\small{\expandafter\string\csname #1\endcsname} &
          \small{\csname #1onlybaseunits\endcsname} &
1043
          \small{\csname #1onlyderivedunits\endcsname} &
1044
          \small{\csname #1onlyalternateunits\endcsname}
1045
        \end{tabular}
1046
     \end{center}
1047
1048 }%
1049 \NewDocumentCommand{\checkconstant}{ m }{\%
1050
      \begin{center}
        \begin{tabular}{>{\centering}p{4cm} >{\centering}p{3cm}} >{\centering}p{4cm} >{\centering}p{3cm}}
1051
          name & base & derived & alternate \tabularnewline
1052
          \ttfamily\small{\expandafter\string\csname #1\endcsname} &
1053
          \small{\csname #1onlybaseunits\endcsname} &
1054
1055
          \small{\csname #1onlyderivedunits\endcsname} &
          \small{\csname #1onlyalternateunits\endcsname} \tabularnewline
1056
          symbol & approximate & precise \tabularnewline
1057
          \small{\csname #1mathsymbol\endcsname} &
1058
          \small{\csname #1approximatevalue\endcsname} &
1059
          \small{\csname #1precisevalue\endcsname} \tabularnewline
1060
        \end{tabular}
1061
1062
     \end{center}
1063 }%
```

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\absolutevalue*	\chemicalenergy
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\acceleration	\cmagneticfieldvector
·	• • • • • • • • • • • • • • • • • • • •
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