The mandi Package

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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

v3.0.0j	
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 v3.0.0j dated 2021-04-04 and is a stable build.

1.2 Package Options

N 2021-01-30 N 2021-01-30 units=\(type of unit\)
preciseconstants=\(boolean\)

(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}}\ensuremath{\mbox{\veeec$}}\ensuremath{\mbox{$\wedge$}}\ensuremath{\mbox{$P.29$}}\ensuremath{\mbox{$\veeec}}\ensuremath{\mbox{\rangle}}\ensuremath{\mbox{\wedge}}\ensuremath{\mbox{\rangle}}\ens$

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 $\mbox{\mbox{mivector}}^{P.30}$ to typeset symbolic vectors with components. Use the aliases $\mbox{\mbox{\mbox{direction}}}^{P.30}$ or $\mbox{\mbox{\mbox{\mbox{unitvector}}}^{P.30}$ to typeset a direction or unit vector.

Use $physicsproblem^{\to P.33}$ and $parts^{\to P.33}$ and $problempart^{\to P.33}$ to typeset problems. Use $physicssolution^{\to P.34}$ to typeset step-by-step mathematical solutions. Use $glowscriptblock^{\to P.40}$ to typeset glowscript programs. Use plowscript to typeset programs to type program to type programs to type program to type p

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

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 \vectormomentum{mv_x,mv_y,mv_z} but instead the generic \mivector{mv_x,mv_y,mv_z} instead.

3.1.2 Checking Physical Quantities

N 2021-02-16

\checkquantity{\(name \) }

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 \(^{\top} P.30\) 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				
	\angularfrequency{(magnitude)}							
	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

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

\areachargedensity{\(magnitude \) \}

derived

C/s

base

A

	name \current	base A	derived A	alternate A
N 2021-02-24	$\label{lem:currentdensity} $$ \currentdensity{(magnitude currentdensityvector{(c_1, } \currentdensity{(c_1, } \currentdensity{(c_1, } \currentdensity{(c_2, } \curre$	\ldots , $c_n \rangle \}$		
	name \currentdensity	base m ⁻² ⋅A		$\begin{array}{c} {\rm alternate} \\ {\rm A}/{\rmm^2} \end{array}$
	$\verb \dielectricconstant{ } {\it agn}$	$itude angle \}$		
	name \dielectricconstant	base	derived	alternate
N 2021-02-24	$\label{lem:displacement} $$ \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,\dots, c_n) $$ $$ \operatorname{ctricfield}(c_1,\dots, 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	$_{\rm J}^{\rm alternate}$
	(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:condition} $$ \left(\max(d_{i}) \right) $$ \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	$\label{eq:constraint} $$ \operatorname{constraint} (magnitude) $$ \operatorname{constraint} (c_1, \dots, c_n) $$ \operatorname{constraint} (c_1, \dots, c_n) $$$						
	${\rm name} \\ {\tt \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ $	base $m \cdot s^{-2}$	derived N/kg	alternate N/kg			
	($magnitude$)}					
	${\rm name} \\ {\tt \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ $	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	\linearmassdensity{\langle (magnitude)}					
	${ 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	(n\magneticdipolemomentve) \vectormagneticdipolemoment			
	${\rm name} \\ {\tt \mbox{\tt \m}}}}}}}}}}}}}}}}}}}}}}}}}}}}}}}}}}}}$	$\begin{array}{c} base \\ m^2 \cdot A \end{array}$		alternate J/T
N 2021-02-24	$\label{local_magnetic} $$\max_{magneticfield}(c_1) \le c_1. $$\c_1 = c_1. $$\c_2 = c_2. $$	$,\ldots,c_n\rangle\}$		
	name \magneticfield	$\begin{array}{c} \text{base} \\ \text{kg} \cdot \text{s}^{-2} \cdot \text{A}^{-1} \end{array}$	derived T	$\begin{array}{c} \text{alternate} \\ \text{N/C} \cdot (\text{m/s}) \end{array}$
	\langle magnitude	·)}		
	name \magneticflux	$\begin{array}{c} {\rm base} \\ {\rm m^2 \cdot kg \cdot s^{-2} \cdot A^{-1}} \end{array}$		
	$\mbox{\mbox{$\mbox{mass}${(magnitude)}$}}$			
	name \mass	base kg	derived kg	alternate kg
	$\mbox{\mbox{$\mbox{mobility}{($$\mbox{\mbo			
	name \mobility	$\begin{array}{c} base \\ m^2 \cdot kg \cdot s^{-4} \cdot A^{-1} \end{array}$	$\begin{array}{l} \text{derived} \\ m^2 / V \cdot s \end{array}$	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	$\begin{array}{c} base \\ m \cdot kg \cdot s^{-1} \end{array}$	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				
\relativepermittivity{\(magnitude\)}							
${ m name}$	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	$\begin{array}{c} \text{alternate} \\ \text{J/K} \cdot \text{kg} \end{array}$				
\springstiffness{\langle magnite}	ude }}						
name \springstiffness	base kg·s ⁻²	derived N/m	alternate N/m				
$\arraycolor{\$	(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 [(magamita, 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)} $$$						
	name \velocity	$\begin{array}{c} {\rm base} \\ m\cdot s^{-1} \end{array}$	derived m/s	alternate m/s			
	name \velocityc	base c	derived	$_{\rm c}^{\rm alternate}$			
	$\vert \mbox{volume} \{ \langle magnitude \rangle \}$						
	name \volume	base m ³	derived m ³	$_{m^{3}}^{\mathrm{alternate}}$			
	\volumechargedensity{(magnitude)}						
	${\rm name} \\ {\tt \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ $	$\begin{array}{c} \text{base} \\ \text{m}^{-3} \cdot \text{s} \cdot \text{A} \end{array}$	derived C/m³	alternate C/m ³			
	$\verb \volumemassdensity \{ (magnitude) \} (magnitude) (m$	<i>le</i> }}					
	${ m name}$ \volumemassdensity	$\begin{array}{c} base \\ m^{-3} \cdot kg \end{array}$	$\begin{array}{c} \text{derived} \\ \text{kg} / \text{m}^3 \end{array}$	$\begin{array}{c} {\rm alternate} \\ {\rm kg/m^3} \end{array}$			
	\wavelength{\lambda magnitude \range}						
	name \wavelength	base m	derived m	alternate m			
N 2021-02-24	$\label{eq:local_angle_equation} $$ \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{\((name\))} \[\((derived units\))\] \[\((derived units\))\] \[\((derived units\))\] \[\((derived units\))\] \[\((derived units\))\] \[\((derived units\))\]
```

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
\radian
                               //
\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{\ \ \ \ \ \ \ \ } \\ \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

N 2021-02-02

\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{\ } \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ $	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	$\begin{array}{c} alternate \\ W / m^2 \cdot K^4 \end{array}$
\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 {\((name\))}{\((approximate value\))}{\((precise value\))}{\((base units\))} \[\((derived units\)) \] \((derived units\)) \[\((derived units\)) \]

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 Other Commands for Physics Students

In addition to the $glowscriptblock^{\rightarrow P. 40}$ environment and the $\protect{\protect}\protect\protec$

4.1 Traditional Vector Notation

```
\ensuremath{\mbox{vec}(\symbol)}[\alpha less]$ (use this variant for boldface notation) $$\ensuremath{\mbox{vec*}(\symbol)}[\alpha less]$ (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. This command redefines the default IATEX \vec command.

```
p
\( \vec{p} \)
                                               //
                                                                 oldsymbol{p}_2^{	ext{ball}}
\(\vec{p}_{2}\)
                                               //
\( \vec{p}^{\symup{ball}} \)
                                               11
                                                                 p_{\rm final}
11
                                                                 p ball final
\c \operatorname{p}^{\simeq}_{\symup{final}}_{\symup{ball}} \) \
\( \vec*{p} \)
                                                                 \vec{p}_{\text{ball}}^{\text{max}}
```

```
\dirvec{\(symbol\)}[\(labels\)] (use this variant for boldface notation)
\dirvec*{\(symbol\)}[\(labels\)] (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*\)
```

$\mbox{\mbox{\tt mivector}}[\langle delimiter \rangle] \{\langle c_1, \dots, c_n \rangle\} [\langle units \rangle]$

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 $Matter\ \mathscr{E}$ Interactions.

```
 \begin{array}{c} \langle p_0,p_1,p_2,p_3 \rangle \\ \text{mivector}\{\text{gamma m v_x, gamma m v_y, gamma m v_z} \rangle \\ \text{mivector}\{\text{frac}\{0_1,0_2\}\{x^2\},0,0\} \\ \text{mivector}\{-1,0,0\} \\ \text{mivector}\{-1,0,0\}[\text{velocityonlyderivedunits}] \\ \text{mivector}\{-1,0,0\}[\text{meter}\per\second}] \\ \text{velocity}\{\text{mivector}\{-1,0,0\}\} \\ \end{array}
```

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

```
 \begin{array}{l} \texttt{\direction}[\langle delimiter \rangle] \{\langle c_1, \dots, c_n \rangle\} \\ \texttt{\dunitvector}[\langle delimiter \rangle] \{\langle c_1, \dots, c_n \rangle\} \end{array}
```

Semantic aliases for \mivector.

\changein

Semantic alias for \Delta.

```
N 2021-02-21
                         \doublebars[\langle size \rangle] \{\langle quantity \rangle\}
                                                                                                                                                                (double bars)
                         \doublebars*[\langle size \rangle] \{\langle quantity \rangle\}
                                                                                                                                             (double bars for fractions)
N 2021-02-21
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
                         \agglebrackets[\langle size \rangle] \{\langle quantity \rangle\}
                                                                                                                                                            (angle brackets)
                                                                                                                                         (angle brackets for fractions)
N 2021-02-21
                         \agglebrackets*[\langle size \rangle] \{\langle quantity \rangle\}
N 2021-02-21
                         \parentheses[\langle size \rangle] \{\langle quantity \rangle\}
                                                                                                                                                                (parentheses)
N 2021-02-21
                         \parentheses*[\langle size \rangle] \{\langle quantity \rangle\}
                                                                                                                                             (parentheses for fractions)
```

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

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.

```
\|\cdot\|
                                                                             \|a\|
\[ \doublebars{} \]
\[ \doublebars{\vec{a}} \]
                                                                             \left\| \frac{a}{3} \right\|
\[ \doublebars*{\frac{\ \frac{\vec{a}}{3}} \] \]
1.1
\[\singlebars{}\]
                                                                              |x|
\[ \singlebars{x} \]
                                                                              \left|\frac{x}{3}\right|
\[ \singlebars*{\frac{x}{3}} \]
\[ \]  \[ \singlebars[\Bigg]{\frac{x}{3}} \]
                                                                             <·>
                                                                             \langle a \rangle
\[ \anglebrackets{} \]
\[ \anglebrackets{\vec{a}} \]
\[ \anglebrackets*{\frac{\vec{a}}{3}} \]
(·)
                                                                             (x)
\[ \parentheses{} \]
\[ \parentheses{x} \]
\[ \parentheses *{\frac{x}{3}} \]
\[\] \[ \parentheses[\Bigg]{\frac{x}{3}} \]
```

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

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

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}  \[ \colvec{1,2,3} \] \[ \rowvec{1,2,3} \] \[ \colvec{x_0,x_1,x_2,x_3} \] \[ \colvec{x_0,x_1,x_2,x_3} \] \\ [ \rowvec{x_0,x_1,x_2,x_3} \] \\ \[ \rowvec{x_0,x_1,x_2,x_3} \] \\ \left( x_0 \\ x_1 \\ x_2 \\ x_3 \end{array} \] \\ \left( x^0 x^1 x^2 x^3 \right) \]
```

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

Commands for powers of ten and scientific notation.

4.2 Problems and Annotated Problem Solutions

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{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

```
\begin{physicssolution}
    ⟨solution steps⟩
\end{physicssolution}
```

(use this variant for numbered steps)

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 \setminus \setminus
                                                                                                                        (2)
                                                                                        z = x - y
 z &= x - y \\
y &= x - z
                                                                                        y = x - z
                                                                                                                        (3)
\end{physicssolution}
\begin{physicssolution*}
 x &= y + z \\
 z &= x - y \\
y &= x - z
                                                                                        x = y + 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 \reason{This is a reason.}
                                                                                                  (5)
                                                        z = x - y
                                                                   This is a reason too.
 z \&= x - y \geq \{This is a reason too.} \
                                                                                                  (6)
 y &= x - z \reason{final answer}
                                                        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.} \
                                                         x = y + z
                                                                      This is a reason.
 y &= x - z \reason{final answer}
\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. 34 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{limit} $$ \sum_{(aption)} {(abel)} {(image)} $$$

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 37.
```

```
\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 \ref{reffig2} is nice.
It's captioned \nameref{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 38.
```

4.3 Coordinate-Free and Index Notation

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

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

      \veccomp*{(symbol)}
      (use this variant for index vector notation)

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

      \tencomp*{(symbol)}
      (use this variant for index tensor notation)
```

Conforms to ISO 80000-2 notation.

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

```
\valence{\langle index \rangle} \\langle index \rangle \langle index \rangle index \rang
```

Typesets tensor valence. The starred variant typesets it horizontally.

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

A vector is a \binom{1}{0} tensor.

A vector is a \binom{1}{0} tensor.

A vector is a \binom{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.

```
\(\contraction{1,2} \)\\\\(\contraction*{1,2} \)\\ C_{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.

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

5 GlowScript and VPython Program Listings

GlowScript² and VPython³ are programming environments (both use Python) frequently used in introductory physics to introduce students for modeling physical systems. mandi makes including code listings very simple for students.

5.1 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 GlowScript.org. Clicking anywhere in the code window will open the link in the default browser. A caption is mandatory, and a label is internally generated. The listing always begins on a new page. A URL shortening utility is recommended to keep the URL from getting unruly. For convenience, https:// is automatically prepended to the URL and can thus be omitted. The program must exist in a public, not private, folder.

²https://glowscript.org

³https://vpython.org

```
\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 42.
```

5.2 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 39 Fnet = Fgrav + Fspringpball = pball + Fnet * deltat 40 ball.pos = ball.pos + (pball / mball) * deltat 41 spring.axis = ball.pos - ceiling.pos 42 t = t + deltat43

```
\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 44.
```

5.3 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 *.

6 Commands Specific to Matter & Interactions

mandi comes with an accessory package mandiexp which includes commands specific to *Matter & Interactions*⁴. 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. Note that mandiexp requires, and loads, mandi but mandi doesn't require, and doesn't load, mandiexp.

6.1 The Momentum Principle

```
\lhsmomentumprinciple
                                                                 (LHS of delta form, bold vectors)
\rhsmomentumprinciple
                                                                 (RHS of delta form, bold vectors)
\lhsmomentumprincipleupdate
                                                               (LHS of update form, bold vectors)
\rhsmomentumprincipleupdate
                                                               (RHS of update form, bold vectors)
\momentumprinciple
                                                                         (delta form, bold vectors)
                                                                       (update form, bold vectors)
\momentumprincipleupdate
\lhsmomentumprinciple*
                                                                (LHS of delta form, arrow vectors)
\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{sys}}
                                                                                                \boldsymbol{F}_{\text{sys, net}} \Delta t
\( \lhsmomentumprinciple \)
                                                                                                p_{\text{sys,final}}
\(\rhsmomentumprinciple\)
                                                               11
                                                                                                \boldsymbol{p}_{\mathrm{sys,initial}} + \boldsymbol{F}_{\mathrm{sys,net}} \, \Delta t
\(\lhsmomentumprincipleupdate \)
                                                                                                \Delta \boldsymbol{p}_{\mathrm{sys}} = \boldsymbol{F}_{\mathrm{sys,net}} \, \Delta t
\(\rhsmomentumprincipleupdate\)
\( \momentumprinciple \)
                                                                                                p_{\text{sys,final}} = p_{\text{sys,initial}} + F_{\text{sys,net}} \Delta t
\(\momentumprincipleupdate\)
                                                                                                \Delta \vec{p}_{\rm sys}
\(\lhsmomentumprinciple*\)
                                                               11
                                                                                                \hat{F}_{\text{sys.net}} \Delta t
\(\rhsmomentumprinciple* \)
\(\lhsmomentumprincipleupdate*\)
                                                                                                \vec{p}_{\text{sys,final}}
\(\rhsmomentumprincipleupdate* \)
                                                                                                \overrightarrow{p}_{\mathrm{sys,initial}} + \overrightarrow{F}_{\mathrm{sys,net}} \, \Delta t
\(\momentumprinciple*\)
\(\momentumprincipleupdate* \)
                                                                                                \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

```
\lambda (LHS of delta form) \rhsenergyprinciple [(+process...)] (RHS of delta form)
```

⁴See Matter & Interactions and https://matterandinteractions.org/ for details

```
\lambda (LHS of update form) \rhsenergyprincipleupdate [\((+process...\))] (RHS of update form) \energyprinciple [\((+process...\))] (delta form) \energyprincipleupdate [\((+process...\))] (update form)
```

Variants of command for typesetting the energy principle.

```
\Delta E_{\mathrm{sys}}
                                                                              W_{\rm ext}
\(\lhsenergyprinciple\)
                                                     11
\(\rhsenergyprinciple\)
                                                                              W_{\mathrm{ext}} + Q
\(\rhsenergyprinciple[+Q]\)
                                                                              \begin{split} \Delta E_{\rm sys} &= W_{\rm ext} \\ \Delta E_{\rm sys} &= W_{\rm ext} + Q \end{split}
\( \energyprinciple \)
\(\energyprinciple[+Q]\)
\(\lhsenergyprincipleupdate\)
                                                                              E_{\rm sys,final}
\(\rhsenergyprincipleupdate\)
                                                                              E_{\rm sys,initial} + W_{\rm ext}
\(\rhsenergyprincipleupdate[+Q]\)
                                                                             E_{\text{sys,initial}} + W_{\text{ext}} + Q
\(\energyprincipleupdate\)
                                                                              E_{\text{sys,final}} = E_{\text{sys,initial}} + W_{\text{ext}}
\( \energyprincipleupdate[+Q] \)
                                                                              E_{\text{sys,final}} = E_{\text{sys,initial}} + W_{\text{ext}} + Q
```

6.3 The Angular Momentum Principle

```
\lhsangularmomentumprinciple
                                                                (LHS of delta form, bold vectors)
\rhsangularmomentumprinciple
                                                                (RHS of delta form, bold vectors)
\lhsangularmomentumprincipleupdate
                                                              (LHS of update form, bold vectors)
\rhsangularmomentumprincipleupdate
                                                              (RHS of update form, bold vectors)
\angularmomentumprinciple
                                                                       (delta form, bold vectors)
\angularmomentumprincipleupdate
                                                                      (update form, bold vectors)
\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
\(\angularmomentumprinciple\)
                                                                                     //
\( \angularmomentumprincipleupdate \)
\( \lhsangularmomentumprinciple* \)
                                                                                     //
                                                                                                          \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\$ \pro

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 [$\langle label \rangle$]

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{3.0.0j}
2 \def\mandi@Date{2021-04-04}
3 \NeedsTeXFormat{LaTeX2e}[1999/12/01]
4 \providecommand\DeclareRelease[3]{}
5 \providecommand\DeclareCurrentRelease[2]{}
6 \DeclareRelease{v3.0.0j}{2021-04-04}{mandi.sty}
7 \DeclareCurrentRelease{v\mandi@Version}{\mandi@Date}
8 \ProvidesPackage{mandi}
9 [\mandi@Date\space v\mandi@Version\space Macros for introductory physics]
Define a convenient package version command.
```

 $10 \verb| newcommand*{\maindiversion}{v \verb| mandi@Version \verb| space dated \verb| mandi@Date||}|$

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 IATEX kernel. Because unicode-math is required, all documents using mandi must be compiled with an engine that supports Unicode. We recommend LuaIATEX.

```
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.

 $16 \ \texttt{Scale=MatchLowercase,range=\{\{mathscr,\{mathbfscr\}\}\}} \ \texttt{XITS} \ \ \texttt{Math}\} \\$

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
29 \RequirePackage{iftex}
                                        % needed for requiring LuaLaTeX
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
    <5.5-6.5> vect6
42
   <6.5-7.5> vect7
43
    <7.5-8.5> vect8
    <8.5-9.5> vect9
   <9.5-> vect10
46
47 }{}%
   The core unit engine has been completely rewritten in expl3 for both clarity and power.
   Generic internal selectors.
48 \newcommand*{\mandi@selectunits}{}
49 \newcommand*{\mandi@selectprecision}{}
   Specific internal selectors.
50 \newcommand*{\mandi@selectapproximate}[2]{#1}
                                                   % really \Offirstoftwo
51 \newcommand*{\mandi@selectprecise}[2]{#2}
                                                   % really \@secondoftwo
                                                   % really \@firstofthree
52 \newcommand*{\mandi@selectbaseunits}[3]{#1}
                                                   % really \@secondofthree
53 \newcommand*{\mandi@selectderivedunits}[3]{#2}
54 \neq 1 \mexicon mand*{\mandi@selectal ternate units}[3]{#3} % really \@thirdofthree
   Document level global switches.
55 \NewDocumentCommand{\alwaysusebaseunits}{}
    {\renewcommand*{\mandi@selectunits}{\mandi@selectbaseunits}}%
56
57 \NewDocumentCommand{\alwaysusederivedunits}{}
    {\tt \{\normand*{\normand*{\normandi@selectunits}}{\normandi@selectderivedunits}}}\%
59 \NewDocumentCommand{\alwaysusealternateunits}{}
    {\renewcommand*{\mandi@selectunits}}\%
61 \NewDocumentCommand{\alwaysuseapproximateconstants}{}
    {\renewcommand*{\mandi@selectprecision}{\mandi@selectapproximate}}%
63 \NewDocumentCommand{\alwaysusepreciseconstants}{}
    {\renewcommand*{\mandi@selectprecision}{\mandi@selectprecise}}%
   Document level localized variants.
66 \NewDocumentCommand{\hereusederivedunits}{ m }{\begingroup\alwaysusederivedunits#1\endgroup}}%
67 \NewDocumentCommand{\hereusealternateunits}{ m }{\begingroup\alwaysusealternateunits#1\endgroup}%
68 \NewDocumentCommand{\hereuseapproximateconstants}{ m }{\begingroup\alwaysuseapproximateconstants#1\endgroup}%
69 \NewDocumentCommand{\hereusepreciseconstants}{ m }{\begingroup\alwaysusepreciseconstants#1\endgroup}%
   Document level environments.
70 \NewDocumentEnvironment{usebaseunits}{}{\alwaysusebaseunits}{}%
71 \NewDocumentEnvironment{usederivedunits}{}{\alwaysusederivedunits}{}%
72 \NewDocumentEnvironment{usealternateunits}{}{\alwaysusealternateunits}{}}
73 \NewDocumentEnvironment{useapproximateconstants}{}{\alwaysuseapproximateconstants}{}{}
74 \NewDocumentEnvironment{usepreciseconstants}{}{\alwaysusepreciseconstants}{}}
   mandi now has a key-value interface, implemented with pgfopts and pgfkeys. There are two options:
units ^{\rightarrow P.6}, with values base, derived, or alternate selects the default form of units
preciseconstants P.6, with values true and false, selects precise numerical values for constants rather than approximate
values.
```

First, define the keys. The key handlers require certain commands defined by the unit engine.

```
75 \newif\ifusingpreciseconstants
76 \pgfkeys{%
     /mandi/options/.cd,
77
     initial@setup/.style={%
78
       /mandi/options/buffered@units/.initial=alternate,%
79
     },%
80
81
     preciseconstants/.is if=usingpreciseconstants,%
82
    units/.is choice,%
83
    units/.default=derived.%
84
     units/alternate/.style={/mandi/options/buffered@units=alternate},%
     units/base/.style={/mandi/options/buffered@units=base},%
     units/derived/.style={/mandi/options/buffered@units=derived},%
88 }%
    Process the options.
89 \ProcessPgfPackageOptions{/mandi/options}
    Write a banner to the console showing the options in use.
90 \typeout{}%
91 \typeout{mandi: You are using mandi \mandiversion.}%
92 \typeout{mandi: This package requires LuaLaTeX.}%
93 \typeout{mandi: This package changes the default math font.}%
94 \typeout{mandi: This package redefines the \protect\vec\space command.}%
95 \typeout{mandi: Loadtime options...}
    Complete the banner by showing currently selected options. The value of the units P.6 key is used in situ to set the
default units.
96 \newcommand*{\mandi@do@setup}{%
     \csname alwaysuse\pgfkeysvalueof{/mandi/options/buffered@units}units\endcsname%
     \typeout{mandi: You will get \pgfkeysvalueof{/mandi/options/buffered@units}\space units.}%
     \ifusingpreciseconstants
99
100
       \alwaysusepreciseconstants
       \typeout{mandi: You will get precise constants.}%
101
     \else
102
       \alwaysuseapproximateconstants
103
       \typeout{mandi: You will get approximate constants.}%
104
105
     \fi
106
     \typeout{}%
107 }%
108 \mandi@do@setup
    Define a setup command that overrides the loadtime options when called with new options. A new banner is written to
the console.
109 \NewDocumentCommand{\mandisetup}{ m }{%
     \IfValueT{#1}{%
110
       \pgfqkeys{/mandi/options}{#1}
111
112
       \typeout{}%
       \typeout{mandi: mandisetup options...}
113
114
       \mandi@do@setup
115
    }%
116 }%
    Define units to be used with the unit engine. All single letter macros are now gone. We basically absorbed and adapted
the now outdated Slunits package. We make use of \symup{...} from the unicode-math package.
117 \NewDocumentCommand{\per}{}{\ensuremath{\,/\,}}
118 \NewDocumentCommand{\usk}{}{\ensuremath{\,\cdot\,}}
```

119 \NewDocumentCommand{\unit}{ m m }{\ensuremath{{#1}\;{#2}}}
120 \NewDocumentCommand{\ampere}{}{\ensuremath{\symup{A}}}

```
121 \NewDocumentCommand{\atomicmassunit}{}{\ensuremath{\symup{u}}}}
122 \NewDocumentCommand{\candela}{}{\ensuremath{\symup{cd}}}
123 \NewDocumentCommand{\coulomb}{}{\ensuremath{\symup{C}}}
124 \NewDocumentCommand{\degree}{}{\ensuremath{^{\circ}}}
125 \NewDocumentCommand{\electronvolt}{}\ensuremath{\symup{eV}}}
126 \NewDocumentCommand{\farad}{}{\ensuremath{\symup{F}}}
127 \NewDocumentCommand{\henry}{}{\ensuremath{\symup{H}}}}
128 \NewDocumentCommand{\hertz}{}{\ensuremath{\symup{Hz}}}}
129 \NewDocumentCommand{\joule}{}{\ensuremath{\symup{J}}}}
130 \NewDocumentCommand{\kelvin}{}\ensuremath{\symup{K}}}
131 \NewDocumentCommand{\kilogram}{}{\ensuremath{\symup{kg}}}
132 \NewDocumentCommand{\lightspeed}{}{\ensuremath{\symup{c}}}
133 \NewDocumentCommand{\meter}{}{\ensuremath{\symup{m}}}
134 \NewDocumentCommand{\metre}{}{\meter}
135 \NewDocumentCommand{\mole}{}{\ensuremath{\symup{mol}}}
136 \NewDocumentCommand{\newton}{}{\ensuremath{\symup{N}}}
137 \NewDocumentCommand{\ohm}{}{\ensuremath{\symup\Omega}}
138 \NewDocumentCommand{\pascal}{}{\ensuremath{\symup{Pa}}}
139 \NewDocumentCommand{\radian}{}{\ensuremath{\symup{rad}}}}
140 \NewDocumentCommand{\second}{}{\ensuremath{\symup{s}}}
141 \NewDocumentCommand{\siemens}{}{\ensuremath{\symup{S}}}}
142 \MewDocumentCommand{\steradian}{}{\ensuremath{\symup{sr}}}
143 \MewDocumentCommand{\tesla}{}{\normand{T}}}
144 \NewDocumentCommand{\volt}{}{\ensuremath{\symup{V}}}}
145 \NewDocumentCommand{\watt}{}{\ensuremath{\symup{W}}}}
146 \NewDocumentCommand{\weber}{}{\ensuremath{\symup{Wb}}}}
147 \NewDocumentCommand{\tothetwo}{}{\ensuremath{^2}}
                                                                  % postfix 2
148 \NewDocumentCommand{\tothethree}{}{\ensuremath{^3}}
                                                                  % postfix 3
149 \NewDocumentCommand{\tothefour}{}{\ensuremath{^4}}
                                                                  % postfix 4
150 \MewDocumentCommand{\inverse}{}{\ensuremath{^{-1}}}
                                                                  % postfix -1
151 \MewDocumentCommand{\totheinversetwo}{}{\ensuremath{^{-2}}}
                                                                  % postfix -2
152 \NewDocumentCommand{\totheinversethree}{}{\ensuremath{^{-3}}} % postfix -3
153 \NewDocumentCommand{\totheinversefour}{}\ensuremath{^{-4}}} % postfix -4
154 \NewDocumentCommand{\emptyunit}{}{\ensuremath{\mdlgwhtsquare}}
```

Defining a new scalar quantity. I am very much aware that this family of commands doesn't yet correctly abide by the LATEX3 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.

```
155 \NewDocumentCommand{\newscalarquantity}{ m m 0{#2} 0{#2} }{%
156
     \expandafter\newcommand\csname #1\endcsname[1]{##1\,\mandi@selectunits{#2}{#3}{#4}}%
157
     \expandafter\newcommand\csname #1value\endcsname[1]{##1}%
     \expandafter\newcommand\csname #1baseunits\endcsname[1]{##1\,\mandi@selectbaseunits{#2}{#3}{#4}}%
158
     \expandafter\newcommand\csname #1derivedunits\endcsname[1]{##1\,\mandi@selectderivedunits{#2}{#3}{#4}}%
159
     \expandafter\newcommand\csname #1alternateunits\endcsname[1]{##1\,\mandi@selectalternateunits{#2}{#3}{#4}}%
160
     \expandafter\newcommand\csname #1onlybaseunits\endcsname{\mandi@selectbaseunits{#2}{#3}{#4}}%
161
     \expandafter\newcommand\csname #1onlyderivedunits\endcsname{\mandi@selectderivedunits{#2}{#3}{#4}}%
162
163
     \expandafter\newcommand\csname #1onlyalternateunits\endcsname{\mandi@selectalternateunits{#2}{#3}{#4}}%
164 }%
```

Redefining a new scalar quantity.

```
165 \NewDocumentCommand{\renewscalarquantity}{ m m O{#2} O{#2} }{%
     \expandafter\renewcommand\csname #1\endcsname[1]{##1\,\mandi@selectunits{#2}{#3}{#4}}%
166
     \expandafter\renewcommand\csname #1value\endcsname[1]{##1}%
167
168
     \expandafter\renewcommand\csname #1baseunits\endcsname[1]{##1\,\mandi@selectbaseunits{#2}{#3}{#4}}%
     \expandafter\renewcommand\csname #1derivedunits\endcsname[1]{##1\,\mandi@selectderivedunits{#2}{#3}{#4}}%
169
170
     \expandafter\renewcommand\csname #1alternateunits\endcsname[1]{##1\.\mandi@selectalternateunits{#2}{#3}{#4}}%
     \expandafter\renewcommand\csname #1onlybaseunits\endcsname{\mandi@selectbaseunits{#2}{#3}{#4}}%
171
     \expandafter\renewcommand\csname #1onlyderivedunits\endcsname{\mandi@selectderivedunits{#2}{#3}{#4}}%
172
     \expandafter\renewcommand\csname #1onlyalternateunits\endcsname{\mandi@selectalternateunits{#2}{#3}{#4}}%
173
```

```
174 }%
```

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

```
175 \NewDocumentCommand{\newvectorquantity}{ m m 0{#2} 0{#2} }{%

176 \newscalarquantity{#1}{#2}[#3][#4]

177 \expandafter\newcommand\csname vector#1\endcsname[1]{\expandafter\csname #1\endcsname{\mivector{##1}}}%

178 \expandafter\newcommand\csname #1vector\endcsname[1]{\expandafter\csname #1\endcsname{\mivector{##1}}}%

179 }%
```

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

```
180 \NewDocumentCommand{\renewvectorquantity}{ m m O{#2} O{#2} }{%
181 \renewscalarquantity{#1}{#2}[#3][#4]
182 \expandafter\renewcommand\csname vector#1\endcsname[1]{\expandafter\csname #1\endcsname{\mivector{##1}}}%
183 \expandafter\renewcommand\csname #1vector\endcsname[1]{\expandafter\csname #1\endcsname{\mivector{##1}}}%
184 }%
```

Defining a new physical constant.

```
185 \NewDocumentCommand{\newphysicalconstant}{ m m m m 0{#5} 0{#5} }{%
     \expandafter\newcommand\csname #1\endcsname
186
187
       {\mandi@selectprecision{#3}{#4}\,\mandi@selectunits{#5}{#6}{#7}}%
     \expandafter\newcommand\csname #1mathsymbol\endcsname{\ensuremath{#2}}%
188
     \expandafter\newcommand\csname #1approximatevalue\endcsname{\ensuremath{#3}}%
189
     \expandafter\newcommand\csname #1precisevalue\endcsname{\ensuremath{#4}}%
190
     \expandafter\newcommand\csname #1baseunits\endcsname
191
       {\mandi@selectprecision{#3}{#4}\,\mandi@selectbaseunits{#5}{#6}{#7}}%
192
     \expandafter\newcommand\csname #1derivedunits\endcsname
193
       {\mandi@selectprecision{#3}{#4}\,\mandi@selectderivedunits{#5}{#6}{#7}}%
194
     \expandafter\newcommand\csname #1alternateunits\endcsname
195
       {\mandi@selectprecision{#3}{#4}\,\mandi@selectalternateunits{#5}{#6}{#7}}%
196
     \expandafter\newcommand\csname #1onlybaseunits\endcsname
197
       {\mode @select baseunits $\{ 45 \} $\{ 46 \} $\{ 47 \} \} }
198
     \expandafter\newcommand\csname #1onlyderivedunits\endcsname
199
200
       {\mandi@selectderivedunits{#5}{#6}{#7}}%
     \expandafter\newcommand\csname #1onlyalternateunits\endcsname
201
       {\mandi@selectalternateunits{#5}{#6}{#7}}%
202
203 }%
```

Redefining a new physical constant.

```
204 \NewDocumentCommand{\renewphysicalconstant}{ m m m m 0{#5} 0{#5} }{%}
     \expandafter\renewcommand\csname #1\endcsname
205
       {\mandi@selectprecision{#3}{#4}\,\mandi@selectunits{#5}{#6}{#7}}%
206
     \expandafter\renewcommand\csname #1mathsymbol\endcsname{\ensuremath{#2}}%
207
     \expandafter\renewcommand\csname #1approximatevalue\endcsname{\ensuremath{#3}}%
208
     \expandafter\renewcommand\csname #1precisevalue\endcsname{\ensuremath{#4}}%
209
210
     \expandafter\renewcommand\csname #1baseunits\endcsname
211
       {\mandi@selectprecision{#3}{#4}\,\mandi@selectbaseunits{#5}{#6}{#7}}%
     \expandafter\renewcommand\csname #1derivedunits\endcsname
212
213
       {\mandi@selectprecision{#3}{#4}\,\mandi@selectderivedunits{#5}{#6}{#7}}%
     \expandafter\renewcommand\csname #1alternateunits\endcsname
214
       215
     \expandafter\renewcommand\csname #1onlybaseunits\endcsname
216
217
       {\main} {\mandi@selectbaseunits{#5}{#6}{#7}}%
     \expandafter\renewcommand\csname #1onlyderivedunits\endcsname
218
       {\mandi@selectderivedunits{#5}{#6}{#7}}%
219
220
     \expandafter\renewcommand\csname #1onlyalternateunits\endcsname
221
       {\mandi@selectalternateunits{#5}{#6}{#7}}%
222 }%
```

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.

```
223 \newvectorquantity{acceleration}%
     {\meter\usk\second\totheinversetwo}%
225
     [\newton\per\kilogram]%
226
     [\meter\per\second\tothetwo]%
227 \newscalarquantity{amount}%
228
     {\mole}%
229 \newvectorquantity{angularacceleration}%
     {\radian\usk\second\totheinversetwo}%
230
     [\radian\per\second\tothetwo]%
231
     [\radian\per\second\tothetwo]%
232
233 \newscalarquantity{angularfrequency}%
     {\radian\usk\second\inverse}%
     [\radian\per\second]%
235
236
     [\radian\per\second]%
237 %\ifmandi@rotradians
238 % \newphysicalquantity{angularimpulse}%
        {\meter\tothetwo\usk\kilogram\usk\second\inverse\usk\radian\inverse}%
239 %
240 %
        [\joule\usk\second\per\radian]%
241 %
        [\newton\usk\meter\usk\second\per\radian]%
      \newphysicalquantity{angularmomentum}%
242 %
        {\meter\tothetwo\usk\kilogram\usk\second\inverse\usk\radian\inverse}%
243 %
        [\kilogram\usk\meter\tothetwo\per(\second\usk\radian)]%
244 %
        [\newton\usk\meter\usk\second\per\radian]%
245 %
246 %\else
     \newvectorquantity{angularimpulse}%
247
       {\meter\tothetwo\usk\kilogram\usk\second\inverse}%
248
       [\kilogram\usk\meter\tothetwo\per\second]% % also \joule\usk\second
249
       250
     \newvectorquantity{angularmomentum}%
251
       {\meter\tothetwo\usk\kilogram\usk\second\inverse}%
252
       [\kilogram\usk\meter\tothetwo\per\second] % % also \joule\usk\second
253
       [\kilogram\usk\meter\tothetwo\per\second]% % also \newton\usk\meter\usk\second
254
255 %\fi
256 \newvectorquantity{angularvelocity}%
     {\radian\usk\second\inverse}%
257
     [\radian\per\second]%
258
     [\radian\per\second]%
259
260 \newscalarquantity{area}%
     {\meter\tothetwo}%
262 \newscalarquantity{areamassdensity}%
263
     {\meter\totheinversetwo\usk\kilogram}%
     [\kilogram\per\meter\tothetwo]%
264
     [\kilogram\per\meter\tothetwo]%
265
266 \newscalarquantity{areachargedensity}%
     {\meter\totheinversetwo\usk\second\usk\ampere}%
     [\coulomb\per\meter\tothetwo]%
268
     [\coulomb\per\meter\tothetwo]%
269
270 \newscalarquantity{capacitance}%
     {\meter\totheinversetwo\usk\kilogram\inverse\usk\second\tothefour\usk\ampere\tothetwo}%
     [\farad]%
272
     [\coulomb\per\volt]% % also \coulomb\tothetwo\per\newton\usk\meter, \second\per\ohm
274 \newscalarquantity{charge}%
     {\ampere\usk\second}%
276
     [\coulomb]%
     [\coulomb]% % also \farad\usk\volt
277
```

```
278 \newvectorquantity{cmagneticfield}%
     {\meter\usk\kilogram\usk\second\totheinversethree\usk\ampere\inverse}%
279
     [\volt\per\meter]%
280
     [\newton\per\coulomb]%
281
282 \newscalarquantity{conductance}%
     {\meter\totheinversetwo\usk\kilogram\inverse\usk\second\tothethree\usk\ampere\tothetwo}%
     [\siemens]%
     [\ampere\per\volt]%
285
286 \newscalarquantity{conductivity}%
     [\siemens\per\meter]%
288
     [(\ampere\per\meter\tothetwo)\per(\volt\per\meter)]%
289
290 \newscalarquantity{conventionalcurrent}%
     {\ampere}%
292
     [\coulomb\per\second]%
     [\ampere]%
293
294 \newscalarquantity{current}%
     {\ampere}%
296 \newscalarquantity{currentdensity}%
     {\meter\totheinversetwo\usk\ampere}%
     [\coulomb\usk\second\per\meter\tothetwo]%
     [\ampere\per\meter\tothetwo]%
299
300 \newscalarquantity{dielectricconstant}%
302 \newvectorquantity{displacement}%
     {\meter}
304 \newscalarquantity{duration}%
     {\second}%
306 \newvectorquantity{electricdipolemoment}%
     {\meter\usk\second\usk\ampere}%
307
     [\coulomb\usk\meter]%
308
     [\coulomb\usk\meter]%
310 \newvectorquantity{electricfield}%
     {\meter\usk\kilogram\usk\second\totheinversethree\usk\ampere\inverse}%
     [\volt\per\meter]%
312
     [\newton\per\coulomb]%
314 \newscalarquantity{electricflux}%
    {\meter\tothethree\usk\kilogram\usk\second\totheinversethree\usk\ampere\inverse}%
315
     [\volt\usk\meter]%
     [\newton\usk\meter\tothetwo\per\coulomb]%
318 \newscalarquantity{electricpotential}%
     {\meter\tothetwo\usk\kilogram\usk\second\totheinversethree\usk\ampere\inverse}}
319
     [\volt]%
320
     [\joule\per\coulomb]%
321
322 \newscalarquantity{electroncurrent}%
     {\second\inverse}%
     [\ensuremath{\symup{e}}\per\second]%
     [\ensuremath{\symup{e}}\per\second]%
326 \newscalarquantity{emf}%
     {\meter\tothetwo\usk\kilogram\usk\second\totheinversethree\usk\ampere\inverse}%
327
     [\volt]%
328
     [\joule\per\coulomb]%
329
330 \newscalarquantity{energy}%
     {\meter\tothetwo\usk\kilogram\usk\second\totheinversetwo}%
331
332
     [\joule]% % also \newton\usk\meter
     [\joule]%
333
334 \newscalarquantity{energydensity}%
     {\meter\inverse\usk\kilogram\usk\second\totheinversetwo}%
```

[\joule\per\meter\tothethree]%

```
[\joule\per\meter\tothethree]%
337
338 \newscalarquantity{energyflux}%
     {\kilogram\usk\second\totheinversethree}%
339
     [\watt\per\meter\tothetwo]%
340
     [\watt\per\meter\tothetwo]%
341
342 \newscalarquantity{entropy}%
     {\meter\tothetwo\usk\kilogram\usk\second\totheinversetwo\usk\kelvin\inverse}%
344
     [\joule\per\kelvin]%
     [\joule\per\kelvin]%
346 \newvectorquantity{force}%
     {\meter\usk\kilogram\usk\second\totheinversetwo}%
347
348
     [\newton]%
     [\newton]% % also \kilogram\usk\meter\per\second\tothetwo
350 \newscalarquantity{frequency}%
     {\second\inverse}%
351
     [\hertz]%
352
     [\hertz]%
353
354 \newvectorquantity{gravitationalfield}%
     {\meter\usk\second\totheinversetwo}%
     [\newton\per\kilogram]%
357
     [\newton\per\kilogram]%
358 \newscalarquantity{gravitationalpotential}%
     {\meter\tothetwo\usk\second\totheinversetwo}%
359
     [\joule\per\kilogram]%
360
     [\joule\per\kilogram]%
361
362 \newvectorquantity{impulse}%
     {\meter\usk\kilogram\usk\second\inverse}%
     [\newton\usk\second]%
364
     [\newton\usk\second]%
365
366 \newscalarquantity{indexofrefraction}%
     {}%
367
368 \newscalarquantity{inductance}%
     {\meter\tothetwo\usk\kilogram\usk\second\totheinversetwo\usk\ampere\totheinversetwo}%
370
     [\volt\usk\second\per\ampere]% % also \square\meter\usk\kilogram\per\coulomb\tothetwo, \Wb\per\ampere
371
372 \newscalarquantity{linearchargedensity}%
     {\meter\inverse\usk\second\usk\ampere}%
     [\coulomb\per\meter]%
374
375
     [\coulomb\per\meter]%
376 \newscalarquantity{linearmassdensity}%
     {\meter\inverse\usk\kilogram}%
377
     [\kilogram\per\meter]%
378
     [\kilogram\per\meter]%
379
380 \newscalarquantity{luminous}%
     {\candela}%
382 \newscalarquantity{magneticcharge}%
     {\meter\usk\ampere}%
384 \newvectorquantity{magneticdipolemoment}%
     {\meter\tothetwo\usk\ampere}%
385
     [\ampere\usk\meter\tothetwo]%
386
     [\joule\per\tesla]%
387
388 \newvectorquantity{magneticfield}%
     {\kilogram\usk\second\totheinversetwo\usk\ampere\inverse}%
389
     [\tesla]%
390
     [\newton\per\coulomb\usk(\meter\per\second)]% % also \Wb\per\meter\tothetwo
391
392 \newscalarquantity{magneticflux}%
     {\c {\tt weter \tothetwo \usk \kilogram \usk \second \tothe inverse \two \usk \ampere \inverse} \%}
393
394
     [\tesla\usk\meter\tothetwo]%
     [\volt\usk\second]% % also \Wb and \joule\per\ampere
```

```
396 \newscalarquantity{mass}%
     {\kilogram}%
397
398 \newscalarquantity{mobility}%
     {\meter\tothetwo\usk\kilogram\usk\second\totheinversefour\usk\ampere\inverse}%
399
     [\meter\tothetwo\per\volt\usk\second]%
400
     [(\meter\per\second)\per(\newton\per\coulomb)]%
401
402 \newscalarquantity{momentofinertia}%
     {\meter\tothetwo\usk\kilogram}%
403
     [\joule\usk\second\tothetwo]%
404
     [\kilogram\usk\meter\tothetwo]%
405
406 \newvectorquantity{momentum}%
     {\meter\usk\kilogram\usk\second\inverse}%
     [\newton\usk\second]%
     [\kilogram\usk\meter\per\second]%
410 \newvectorquantity{momentumflux}%
     {\meter\inverse\usk\kilogram\usk\second\totheinversetwo}%
411
     [\newton\per\meter\tothetwo]%
412
     [\newton\per\meter\tothetwo]%
413
414 \newscalarquantity{numberdensity}%
     {\meter\totheinversethree}%
     [\per\meter\tothethree]%
416
     [\per\meter\tothethree]%
417
418 \newscalarquantity{permeability}%
     {\meter\usk\kilogram\usk\second\totheinversetwo\usk\ampere\totheinversetwo}%
419
420
     [\tesla\usk\meter\per\ampere]%
     [\henry\per\meter]%
421
422 \newscalarquantity{permittivity}%
423
     {\meter\totheinversethree\usk\kilogram\inverse\usk\second\totheinversefour\usk\ampere\tothetwo}%
     [\farad\per\meter]%
424
     [\coulomb\tothetwo\per\newton\usk\meter\tothetwo]%
425
426 \newscalarquantity{planeangle}%
     {\meter\usk\meter\inverse}%
427
428
     [\radian]%
     [\radian]%
429
430 \newscalarquantity{polarizability}%
     {\kilogram\inverse\usk\second\tothefour\usk\ampere\tothetwo}%
431
     [\coulomb\usk\meter\tothetwo\per\volt]%
432
     [\coulomb\usk\meter\per(\newton\per\coulomb)]%
434 \newscalarquantity{power}%
     {\meter\tothetwo\usk\kilogram\usk\second\totheinversethree}%
     [\watt]%
436
     [\joule\per\second]%
437
438 \newvectorquantity{poynting}%
     {\kilogram\usk\second\totheinversethree}%
439
440
     [\watt\per\meter\tothetwo]%
     [\watt\per\meter\tothetwo]%
442 \newscalarquantity{pressure}%
     {\meter\inverse\usk\kilogram\usk\second\totheinversetwo}%
443
     [\pascal]%
444
     [\newton\per\meter\tothetwo]%
445
446 \newscalarquantity{relativepermeability}
447
448 \newscalarquantity{relativepermittivity}%
449
     {}%
450 \newscalarquantity{resistance}%
     {\meter\tothetwo\usk\kilogram\usk\second\totheinversethree\usk\ampere\totheinversetwo}%
451
     [\volt\per\ampere]%
452
453
     [\ohm]%
454 \newscalarquantity{resistivity}%
```

```
{\meter\tothethree\usk\kilogram\usk\second\totheinversethree\usk\ampere\totheinversetwo}%
455
     [\ohm\usk\meter]%
456
     [(\volt\per\meter)\per(\ampere\per\meter\tothetwo)]%
457
458 \newscalarquantity{solidangle}%
     {\meter\tothetwo\usk\meter\totheinversetwo}%
     [\steradian]%
460
     [\steradian]%
462 \newscalarquantity{specificheatcapacity}%
     {\meter\tothetwo\usk\second\totheinversetwo\usk\kelvin\inverse}%
463
     [\joule\per\kelvin\usk\kilogram]%
464
     [\joule\per\kelvin\usk\kilogram]
466 \newscalarquantity{springstiffness}%
     {\kilogram\usk\second\totheinversetwo}%
     [\newton\per\meter]%
468
     [\newton\per\meter]%
469
470 \newscalarquantity{springstretch}% % This is really just a displacement.
     {\meter}%
472 \newscalarquantity{stress}%
     {\meter\inverse\usk\kilogram\usk\second\totheinversetwo}%
     [\newton\per\meter\tothetwo]%
475
476 \newscalarquantity{strain}%
477
478 \newscalarquantity{temperature}%
     {\kelvin}%
480 %\ifmandi@rotradians
481 % \newphysicalquantity{torque}%
482 %
        {\meter\tothetwo\usk\kilogram\usk\second\totheinversetwo\usk\radian\inverse}%
483 %
        [\newton\usk\meter\per\radian]%
484 %
        [\newton\usk\meter\per\radian]%
485 %\else
     \newvectorquantity{torque}%
486
487
       {\meter\tothetwo\usk\kilogram\usk\second\totheinversetwo}%
       [\newton\usk\meter]%
488
       [\newton\usk\meter]%
489
490 %\fi
491 \newvectorquantity{velocity}%
     {\meter\usk\second\inverse}%
492
     [\meter\per\second]%
493
     [\meter\per\second]%
495 \newvectorquantity{velocityc}%
     {\lightspeed}%
496
     []%
497
     [\lightspeed]%
498
499 \newscalarquantity{volume}%
     {\meter\tothethree}%
501 \newscalarquantity{volumechargedensity}%
     {\meter\totheinversethree\usk\second\usk\ampere}%
502
     [\coulomb\per\meter\tothethree]%
503
     [\coulomb\per\meter\tothethree]%
504
505 \newscalarquantity{volumemassdensity}%
     {\meter\totheinversethree\usk\kilogram}%
     [\kilogram\per\meter\tothethree]%
507
508
     [\kilogram\per\meter\tothethree]%
509 \newscalar
quantity
{wavelength}% % This is really just a displacement.
     {\meter}%
511 \newvectorquantity{wavenumber}%
     {\meter\inverse}%
     [\per\meter]%
```

```
[\per\meter]%
514
515 \newscalarquantity{work}%
         {\meter\tothetwo\usk\kilogram\usk\second\totheinversetwo}%
516
          [\joule]%
517
          [\newton\usk\meter]%
518
519 \newscalarquantity{youngsmodulus}% % This is really just a stress.
          {\meter\inverse\usk\kilogram\usk\second\totheinversetwo}%
521
          [\pascal]%
          [\newton\per\meter\tothetwo]%
522
        Define physical constants for introductory physics, again alphabetically for convenience.
523 \newphysicalconstant{avogadro}%
         {\sum_{A}}
          {6\timestento{23}}{6.02214076\timestento{23}}%
525
526
         {\mole\inverse}%
          [\per\mole]%
527
          [\per\mole]%
528
529 \newphysicalconstant{biotsavartconstant}% % alias for \mzofp
         {\sup{\frac{\mu_o}{4\pi c}}}
531
          {\left(-7\right)}{\left(-7\right)}
         {\meter\usk\kilogram\usk\second\totheinversetwo\usk\ampere\totheinversetwo}%
532
          [\henry\per\meter]%
533
          [\tesla\usk\meter\per\ampere]%
534
535 \newphysicalconstant{bohrradius}%
         {\sup\{a_o\}}%
536
          \{5.3 \times \{-11\}\} \{5.2917721067 \times \{-11\}\} \%
537
          {\meter}%
539 \newphysicalconstant{boltzmann}%
         {\sup\{k_B}}%
540
         {1.4\times -23}{1.380649\times -23}%
541
         {\meter\tothetwo\usk\kilogram\usk\second\totheinversetwo\usk\kelvin\inverse}%
542
          [\joule\per\kelvin]%
543
544
          [\joule\per\kelvin]%
545 \mbox{ \newphysicalconstant} \mbox{\coulombconstant} \mbox{\constant} \mbox{\coulombconstant} \m
         {\symup{\frac{1}{4\pi\epsilon_o}}}%
         {9}\times{9}\times{9}
547
         548
          [\meter\per\farad]%
549
          [\newton\usk\meter\tothetwo\per\coulomb\tothetwo]%
551 \newphysicalconstant{earthmass}%
         {\symup{M_{Earth}}}%
552
         \{6.0 \times \{24\}\} \{5.97237 \times \{24\}\} \%
553
         {\kilogram}%
554
555 \newphysicalconstant{earthmoondistance}%
         {\sup\{d_{EM}\}}%
         {3.8\times 1550\times 18}
557
559 \newphysicalconstant{earthradius}%
         {\symup{R_{Earth}}}%
560
         \{6.4 \times \{6.371 \times \{6.371 \times \{6.4\}\} \}
561
         {\meter}%
562
563 \newphysicalconstant{earthsundistance}%
         {\symup{d_{ES}}}%
564
          \{1.5\timestento\{11\}\}\{1.496\timestento\{11\}\}\%
565
         {\meter}%
566
567 \newphysicalconstant{electroncharge}%
         {\sup\{q_e\}}%
568
         {-\elementarychargeapproximatevalue}{-\elementarychargeprecisevalue}%
569
570
          {\ampere\usk\second}%
```

```
[\coulomb]%
571
572
     [\coulomb]%
573 \newphysicalconstant{electronCharge}%
    {\sup{Q_e}}%
574
    {-\elementarychargeapproximatevalue}{-\elementarychargeprecisevalue}%
575
    {\ampere\usk\second}%
576
577
     [\coulomb]%
    [\coulomb]%
578
579 \newphysicalconstant{electronmass}%
    {\symup{m_e}}%
580
    {9.1\times -31}
581
582
    {\kilogram}%
583 \newphysicalconstant{elementarycharge}%
    {\symup{e}}%
    \{1.6\timestento\{-19\}\}\{1.602176634\timestento\{-19\}\}\%
585
    {\ampere\usk\second}%
586
    [\coulomb]%
587
    [\coulomb]%
588
589 \newphysicalconstant{finestructure}%
    {\symup{\alpha}}%
    {\frac{1}{137}}{7.2973525664\times{-3}}%
591
592
593 \newphysicalconstant{hydrogenmass}%
    {\sup_{m_H}}%
594
    {1.7}\times{-27}{1.6737236}\times{-27}}%
595
    {\kilogram}%
597 \newphysicalconstant{moonearthdistance}%
    {\symup{d_{ME}}}%
598
    {3.8\times 1550\times 8}
599
    {\meter}%
600
601 \newphysicalconstant{moonmass}%
602
    {\symup{M_{Moon}}}%
    {7.3}\times{22}}{7.342}\times{22}}%
603
    {\kilogram}%
605 \newphysicalconstant{moonradius}%
    {\symup{R_{Moon}}}%
606
    {1.7\times 6}}{1.7371\times 6}}
607
608
    {\meter}%
609 \newphysicalconstant{mzofp}%
    {\sup{\frac{\mu_o}{4\pi^2}}}
611
    {\tento{-7}}{\tento{-7}}%
    {\meter\usk\kilogram\usk\second\totheinversetwo\usk\ampere\totheinversetwo}%
612
613
     [\henry\per\meter]%
     [\tesla\usk\meter\per\ampere]%
614
615 \newphysicalconstant{neutronmass}%
    {\sup\{m_n\}}%
    {1.7}\times{0.674927471}\times{0.674927471}
617
    {\kilogram}%
618
619 \newphysicalconstant{oofpez}%
    {\symup{\frac{1}{4\pi\epsilon_o}}}%
620
    {9}\times{9}\times{9}
621
    622
     [\meter\per\farad]%
623
     [\newton\usk\meter\tothetwo\per\coulomb\tothetwo]%
624
625 \newphysicalconstant{oofpezcs}%
    {\sum_{c^2}}%
626
627
    {\left(-7\right)}{\left(-7\right)}
    {\meter\usk\kilogram\usk\second\totheinversetwo\usk\ampere\totheinversetwo}%
628
```

629

[\tesla\usk\meter\tothetwo]%

```
[\newton\usk\second\tothetwo\per\coulomb\tothetwo]%
630
631 \newphysicalconstant{planck}%
     {\sup\{h}}%
632
     \{6.6\timestento\{-34\}\}\{6.62607015\timestento\{-34\}\}\%
633
     {\meter\tothetwo\usk\kilogram\usk\second\inverse}%
634
     [\joule\usk\second]%
635
636
     [\joule\usk\second]%
    See https://tex.stackexchange.com/a/448565/218142.
637 \newphysicalconstant{planckbar}%
     {\symup{\lower0.18ex\hbox{\mathchar"AF}\mkern-7mu h}}%
     \{1.1\timestento\{-34\}\}\{1.054571817\timestento\{-34\}\}\%
639
     {\meter\tothetwo\usk\kilogram\usk\second\inverse}%
640
     [\joule\usk\second]%
     [\joule\usk\second]
642
643 \newphysicalconstant{planckc}%
    {\symup{hc}}%
644
    {2.0\times {-25}}{1.98644586\times {-25}}%
645
646
    {\meter\tothethree\usk\kilogram\usk\second\totheinversetwo}%
     [\joule\usk\meter]%
     [\joule\usk\meter]%
649 \newphysicalconstant{protoncharge}%
650
     {\sup\{q_p\}}%
     {+\elementarychargeapproximatevalue}{+\elementarychargeprecisevalue}%
651
     {\ampere\usk\second}%
652
653
     [\coulomb]%
     [\coulomb]%
655 \newphysicalconstant{protonCharge}%
     {\sup{Q_p}}%
656
      \{ + \texttt{\clementary} charge approximate value} \\ \{ + \texttt{\clementary} charge precise value} \\ \% 
657
     {\ampere\usk\second}%
658
659
     [\coulomb]%
660
     [\coulomb]%
661 \newphysicalconstant{protonmass}%
     {\sup\{m_p\}}%
     {1.7\times -27}{1.672621898\times -27}%
663
     {\kilogram}%
664
665 \newphysicalconstant{rydberg}%
    {\sup{R_{\min{ty}}}}
     {1.1\times 1}{1.0973731568508\times 1}
667
     {\meter\inverse}%
668
669 \newphysicalconstant{speedoflight}%
    {\symup{c}}%
     {3\neq 0}
671
672
     {\meter\usk\second\inverse}%
673
     [\meter\per\second]%
     [\meter\per\second]
674
675 \newphysicalconstant{stefanboltzmann}%
     {\symup{\sigma}}%
676
     \label{eq:continuous} $\{5.7\times -8\}\} $\{5.670367\times -8\}\} \%$
677
     {\kilogram\usk\second\totheinversethree\usk\kelvin\totheinversefour}%
678
     [\watt\per\meter\tothetwo\usk\kelvin\tothefour]%
679
     [\watt\per\meter\tothetwo\usk\kelvin\tothefour]
681 \newphysicalconstant{sunearthdistance}%
682
     {\symup{d_{SE}}}%
683
     \{1.5\timestento\{11\}\}\{1.496\timestento\{11\}\}\%
     {\meter}%
684
685 \newphysicalconstant{sunmass}%
     {\symup{M_{Sun}}}%
```

```
687
     {2.0\timestento{30}}{1.98855\timestento{30}}%
     {\kilogram}%
688
689 \newphysicalconstant{sunradius}%
     {\symup{R_{Sun}}}%
690
     {7.0\times 8}}{6.957\times 6.957}
691
     {\meter}%
692
693 \newphysicalconstant{surfacegravfield}%
     {\symup{g}}%
694
     {9.8}{9.807}%
695
     {\meter\usk\second\totheinversetwo}%
696
     [\newton\per\kilogram]%
697
     [\newton\per\kilogram]%
698
699 \newphysicalconstant{universalgrav}%
     {\sup\{G\}}%
700
     \{6.7 \times \{-11\}\} \{6.67408 \times \{-11\}\} \%
701
     {\meter\tothethree\usk\kilogram\inverse\usk\second\totheinversetwo}%
702
     [\newton\usk\meter\tothetwo\per\kilogram\tothetwo]% % also \joule\usk\meter\per\kilogram\tothetwo
703
     [\newton\usk\meter\tothetwo\per\kilogram\tothetwo]%
704
705 \newphysicalconstant{vacuumpermeability}%
     {\symup{\mu_o}}%
     {4\pi -7}}{4\pi -7}}{4\pi -7}}%
707
     {\meter\usk\kilogram\usk\second\totheinversetwo\usk\ampere\totheinversetwo}%
708
     [\henry\per\meter]%
709
     [\tesla\usk\meter\per\ampere]%
710
711 \newphysicalconstant{vacuumpermittivity}%
712
     {\symup{\epsilon_o}}%
     {9 \times {-12}}{8.854187817 \times {-12}}%
713
     {\meter\totheinversethree\usk\kilogram\inverse\usk\second\tothefour\usk\ampere\tothetwo}%
714
     [\farad\per\meter]%
715
     [\coulomb\tothetwo\per\newton\usk\meter\tothetwo]%
716
    Diagnostic commands to provide sanity checks on commands that represent physical quantities and constants.
717 \NewDocumentCommand{\checkquantity}{ m }{%
     % Works for both scalar and vector quantities.
718
719
     \begin{center}
       \begin{tabular}{>{\centering}p{4cm} >{\centering}p{3cm}} >{\centering}p{4cm} >{\centering}p{3cm}}
720
         name & base & derived & alternate \tabularnewline
721
         \ttfamily\small{\expandafter\string\csname #1\endcsname} &
722
         \small{\csname #1onlybaseunits\endcsname} &
723
         \small{\csname #1onlyderivedunits\endcsname} &
724
         \small{\csname #1onlyalternateunits\endcsname}
725
       \end{tabular}
726
     \end{center}
727
728 }%
729 \NewDocumentCommand{\checkconstant}{ m }{%
730
     \begin{center}
       \begin{tabular}{>{\centering}p{4cm} >{\centering}p{3cm}} >{\centering}p{4cm} >{\centering}p{3cm}}
731
         name & base & derived & alternate \tabularnewline
732
         \ttfamily\small{\expandafter\string\csname #1\endcsname} &
733
         \small{\csname #1onlybaseunits\endcsname} &
734
         \small{\csname #1onlyderivedunits\endcsname} &
735
         \small{\csname #1onlyalternateunits\endcsname} \tabularnewline
736
         symbol & approximate & precise \tabularnewline
737
         \small{\csname #1mathsymbol\endcsname} &
738
         \small{\csname #1approximatevalue\endcsname} &
739
         \small{\csname #1precisevalue\endcsname} \tabularnewline
740
       \end{tabular}
741
     \end{center}
742
743 }%
```

A better, intelligent coordinate-free \vec^{\top P. 29} command. Note the use of the e{_^} type of optional argument. This accounts for much of the flexibility and power of this command. Also note the use of the TEX primitives \sb{} and \sp{}. Why doesn't it work when I put spaces around #3 or #4? Because outside of \ExplSyntaxOn...\ExplSyntaxOff, the _character has a different catcode and is treated as a mathematical entity.

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

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

```
744 \RenewDocumentCommand{\vec}{ s m e{_^} }{%
     \ensuremath{%
       % Note the \, used to make superscript look better.
746
       \IfBooleanTF {#1}
747
748
         {\vv{#2}%
                         % * gives an arrow
            \% Use \sp{} primitive for superscript.
749
            % Adjust superscript for the arrow.
750
            \sp{\IfValueT{#4}{\,#4}\vphantom{\smash[t]{\big|}}}
751
752
         }%
         {\symbfit{#2} % no * gives us bold
753
            % Use \sp{} primitive for superscript.
754
            % No superscript adjustment needed.
755
            \sp{\IfValueT{#4}{#4}\vphantom{\smash[t]{\big|}}}
756
         }%
757
       % Use \sb{} primitive for subscript.
758
       \st {\IfValueT{#3}{#3}\vphantom{\smash[b]{|}}}
759
    }%
760
761 }%
```

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

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

```
762 \NewDocumentCommand{\dirvec}{ s m e{_{^{}}} }{%
     \ensuremath{%
       \widetilde{\} \widetilde{\} 
764
         \IfBooleanTF {#1}
765
           {%
766
             #2
767
           }%
768
769
           {%
              \symbfit{#2}
770
           }%
771
          }%
772
         }%
773
774
       \sh\{\IfValueT{#3}{#3}\vphantom{\smash[b]{|}}}
775
       \sp{\IfValueT{#4}{\,#4}\vphantom{\smash[t]{\big|}}}
776
    }%
777
778 }%
    The zero vector.
779 \NewDocumentCommand{\zerovec}{ s }{%
     \IfBooleanTF {#1}
780
       {\vv{0}}%
       {\sup\{0}}%
782
783 }%
    Notation for column and row vectors. \mivector → P.30 is a workhorse command.
 Orginal code provided by @egreg.
See https://tex.stackexchange.com/a/39054/218142.
784 \ExplSyntaxOn
785 \NewDocumentCommand{\mivector}{ O{,} m o }%
```

```
786 {%
                \mi_vector:nn { #1 } { #2 }
787
               \IfValueT{#3}{\; {#3}}
788
789 }%
790 \seq_new:N \l__mi_list_seq
791 \cs_new_protected:Npn \mi_vector:nn #1 #2
793
             \ensuremath{%
                   \seq_set_split:Nnn \l_mi_list_seq { , } { #2 }
794
                   \int_compare:nF { \seq_count:N \l__mi_list_seq = 1 } { \left\langle }
795
                   \seq_use:Nnnn \l__mi_list_seq { #1 } { #1 } { #1 }
796
                   \int_compare:nF { \seq_count:N \l__mi_list_seq = 1 } { \right\rangle }
797
            }%
798
799 }%
800 \NewDocumentCommand{\colvec}{ O{,} m }{%
             \vector_main:nnnn { p } { \\ } { #1 } { #2 }
802 }%
803 \NewDocumentCommand{\rowvec}{ O{,} m }{%
             \vector_main:nnnn { p } { & } { #1 } { #2 }
804
806 \seq_new:N \l__vector_arg_seq
807 \cs_new_protected:Npn \vector_main:nnnn #1 #2 #3 #4 {%
             \seq_set_split:Nnn \l__vector_arg_seq { #3 } { #4 }
808
             \begin{#1NiceMatrix}[r]
809
810
                   \seq_use:Nnnn \l__vector_arg_seq { #2 } { #2 } { #2 }
             \end{#1NiceMatrix}
811
812 }%
813 \ExplSyntaxOff
814 \NewDocumentCommand{\changein}{}{\Delta}
          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.
 815 \end{are} $$15 \end{are} $$11_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{\vert}_{
816 \DeclarePairedDelimiterX{\singlebars}[1]{\lvert}{\rvert}{\ifblank{#1}}{\:\cdot\:}{#1}}
817 \DeclarePairedDelimiterX{\anglebrackets}[1]{\langle}{\rangle}{\ifblank{#1}{\:\cdot\:}{#1}}
 818 \end{align*}  818 \end{align*} $$18 \end{
819 \DeclarePairedDelimiterX{\squarebrackets}[1]{\lbrack}{\rbrack}{\ifblank{#1}{\:\cdot\:}{#1}}
820 \DeclarePairedDelimiterX{\curlybraces}[1]{\lbrace}{\rbrace}{\ifblank{#1}{\:\cdot\:}{#1}}}
           Some semantic aliases. Because of the way \vec<sup>\to P. 29</sup> and \dirvec<sup>\to P. 29</sup> are defined, I reluctantly decided not to
  implement a \magvec command. It would require accounting for too mamy options. So \magnitude \( \text{P.32} \) is the new
  solution.
821 \NewDocumentCommand{\magnitude}{}{\doublebars}
822 \NewDocumentCommand{\norm}{}{\doublebars}
823 \NewDocumentCommand{\absolutevalue}{}{\singlebars}
824 \NewDocumentCommand{\direction}{}{\mivector}
825 \NewDocumentCommand{\unitvector}{}{\mivector}
826 \directlua{%
          luaotfload.add_colorscheme("colordigits",
                {["8000FF"] = {"one", "two", "three", "four", "five", "six", "seven", "eight", "nine", "zero"}})
829 }%
830 \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.
```

{rgb}{0.90,0.90,0.90} % background gray

% new font for listings

831 \newfontfamily{\gsfontfamily}{DejaVuSansMono}

832 \definecolor{gsbggray}

```
833 \definecolor{gsgray}
                               {rgb}{0.30,0.30,0.30} % gray
834 \definecolor{gsgreen}
                               {rgb}{0.00.0.60.0.00} % green
835 \definecolor{gsorange}
                               {rgb}{0.80,0.45,0.12} % orange
836 \definecolor{gspeach}
                               \{rgb\}\{1.00,0.90,0.71\} % peach
837 \definecolor{gspearl}
                               {rgb}{0.94,0.92,0.84} % pearl
838 \definecolor{gsplum}
                                {rgb}{0.74,0.46,0.70} % plum
839 \lstdefinestyle{vpython}{%
                                                       % style for listings
     backgroundcolor=\color{gsbggray},%
                                                       % background color
                                                       % default style
     basicstyle=\colordigits\footnotesize,%
841
     breakatwhitespace=true%
                                                       % break at whitespace
842
                                                       % break long lines
     breaklines=true,%
843
     captionpos=b,%
                                                       % position caption
844
                                                       % STILL DON'T UNDERSTAND THIS
845
     classoffset=1,%
     commentstyle=\color{gsgray},%
                                                       % font for comments
846
     deletekeywords={print},%
847
                                                       % delete keywords from the given language
     emph={self,cls,@classmethod,@property},%
                                                       % words to emphasize
848
     emphstyle=\color{gsorange}\itshape,%
                                                       % font for emphasis
849
     escapeinside={(*@}{@*)},%
                                                       % add LaTeX within your code
850
851
     frame=tb,%
                                                       % frame style
852
     framerule=2.0pt,%
                                                       % frame thickness
     framexleftmargin=5pt,%
                                                       % extra frame left margin
853
     %identifierstyle=\sffamily,%
                                                        % style for identifiers
854
     keywordstyle=\gsfontfamily\color{gsplum},%
                                                       % color for keywords
855
     language=Python,%
                                                       % select language
856
     linewidth=\linewidth,%
                                                       % width of listings
857
     morekeywords={%
                                                       % VPython/GlowScript specific keywords
858
       __future__,abs,acos,align,ambient,angle,append,append_to_caption,%
859
       append_to_title,arange,arrow,asin,astuple,atan,atan2,attach_arrow,%
860
       attach_trail,autoscale,axis,background,billboard,bind,black,blue,border,%
861
       bounding_box,box,bumpaxis,bumpmap,bumpmaps,camera,canvas,caption,capture,%
862
       ceil,center,clear,clear_trail,click,clone,CoffeeScript,coils,color,combin,%
863
       comp,compound,cone,convex,cos,cross,curve,cyan,cylinder,data,degrees,del,%
864
865
       delete,depth,descender,diff_angle,digits,division,dot,draw_complete,%
       ellipsoid, emissive, end_face_color, equals, explog, extrusion, faces, factorial, %
866
       False, floor, follow, font, format, forward, fov, frame, gcurve, gdisplay, gdots, %
867
       get_library,get_selected,ghbars,global,GlowScript,graph,graphs,green,gvbars,%
868
       hat, headlength, headwidth, height, helix, hsv_to_rgb, index, interval, keydown, %
869
       keyup,label,length,lights,line,linecolor,linewidth,logx,logy,lower_left,%
870
871
       lower_right,mag,mag2,magenta,make_trail,marker_color,markers,material,%
       max,min,mouse,mousedown,mousemove,mouseup,newball,norm,normal,objects,%
872
       offset, one, opacity, orange, origin, path, pause, pi, pixel to world, pixels, plot, %
873
874
       points, pos, pow, pps, print, print_function, print_options, proj, purple, pyramid, %
       quad, radians, radius, random, rate, ray, read_local_file, readonly, red, redraw, %
875
       retain, rgb_to_hsv, ring, rotate, round, scene, scroll, shaftwidth, shape, shapes, %
876
877
       shininess, show_end_face, show_start_face, sign, sin, size, size_units, sleep, %
878
       smooth,space,sphere,sqrt,start,start_face_color,stop,tan,text,textpos,%
       texture, textures, thickness, title, trail_color, trail_object, trail_radius, %
879
       trail_type,triangle,trigger,True,twist,unbind,up,upper_left,upper_right,%
880
       userpan, userspin, userzoom, vec, vector, vertex, vertical_spacing, visible, %
881
       visual, vpython, VPython, waitfor, white, width, world, xtitle, yellow, yoffset, %
882
       ytitle%
883
     },%
884
     morekeywords={print,None,TypeError},%
                                                  % additional keywords
885
     morestring=[b]{"""},%
                                                   % treat triple quotes as strings
886
     numbers=left,%
                                                  % where to put line numbers
887
     numbersep=10pt,%
                                                  % how far line numbers are from code
888
     numberstyle=\bfseries\tiny,%
                                                  \% set to 'none' for no line numbers
889
890
     showstringspaces=false,%
                                                  % show spaces in strings
891
     showtabs=false,%
                                                  % show tabs within strings
```

```
stringstyle=\gsfontfamily\color{gsgreen},% % color for strings
892
     upquote=true.%
893
                                                 % how to typeset quotes
894 }%
    Introduce a new, more intelligent glowscriptblock → P. 40 environment.
895 \NewTCBListing[auto counter,list inside=gsprogs]{glowscriptblock}
    { O{} D(){glowscript.org} m }{%
     breakable,%
897
    center,%
898
     code = \newpage,%
899
     %derivpeach,%
900
     enhanced, %
901
     hyperurl interior = https://#2,%
     label = {gs:\thetcbcounter},%
    left = 8mm, %
904
    list entry = \thetcbcounter~~~#3,%
905
    listing only,%
906
    listing style = vpython,%
907
    nameref = \{#3\},%
    title = \texttt{GlowScript} Program \thetcbcounter: #3,%
   width = 0.9\textwidth,%
911 {#1},
912 }%
    A new command for generating a list of GlowScript programs.
913 \NewDocumentCommand{\listofglowscriptprograms}{}{\tcblistof[\section*]{gsprogs}
     {List of \texttt{GlowScript} Programs}}%
    Introduce a new, more intelligent \vpythonfile \rightarrow P. 43 command.
915 \NewTCBInputListing[auto counter,list inside=vpprogs]{\vpythonfile}
    { O{} m m }{%
916
917
    breakable,%
918
    center,%
    code = \newpage,%
919
     %derivgray,%
920
     enhanced, %
921
    hyperurl interior = https://,%
922
     label = {vp:\thetcbcounter},%
923
924
    left = 8mm,%
    list entry = \thetcbcounter~~~#3,%
    listing file = \{\#2\},%
926
    listing only,%
927
   listing style = vpython,%
928
929 nameref = {#3},%
   title = \texttt{VPython} Program \thetcbcounter: #3,%
931 width = 0.9\textwidth,%
   {#1},%
932
933 }%
    A new command for generating a list of VPython programs.
934 \ensuremath{\listofvpythonprograms}{}{\tcblistof[\section*]{vpprogs}}
    {List of \texttt{VPython} Programs}}%
    Introduce a new \glowscriptinline \, P. 45 command.
936 \DeclareTotalTCBox{\glowscriptinline}{ m }{%
    bottom = Opt,%
937
    bottomrule = 0.0mm,%
938
939
   boxsep = 1.0mm,%
    colback = gsbggray,%
```

```
colframe = gsbggray,%
941
942
     left = Opt,%
     leftrule = 0.0mm,%
943
     nobeforeafter.%
944
     right = Opt,%
945
     rightrule = 0.0mm,%
946
947
     sharp corners,%
     tcbox raise base,%
948
     top = 0pt, %
949
     toprule = 0.0mm,%
950
951 }{\lstinline[style = vpython]{#1}}%
```

Define \vpythoninline → P. 45, a semantic alias for VPython in-line listings.

952 \NewDocumentCommand{\vpythoninline}{}{\glowscriptinline}%

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.

```
953 \NewDocumentCommand{\veccomp}{ s m }{%
     % Consider renaming this to \vectorsym.
954
     \IfBooleanTF{#1}
955
     {%
956
       \ensuremath{\symnormal{#2}}%
957
     }%
958
959
       \ensuremath{\symbfit{#2}}%
960
     }%
961
962 }%
963 \NewDocumentCommand{\tencomp}{ s m }{%
     % Consider renaming this to \tensororsym.
964
     \IfBooleanTF{#1}
965
     {%
966
        \ensuremath{\symsfit{#2}}%
967
     }%
968
     {%
969
       \ensuremath{\symbfsfit{#2}}%
970
971
     }%
972 }%
```

An environment for problem statements. The starred variant gives in-line lists.

```
973 \NewDocumentEnvironment{physicsproblem}{ m }{%
     \newpage%
974
     \strut_{\#1}%
975
     \newlist{parts}{enumerate}{2}%
976
     \setlist[parts]{label=\bfseries(\alph*)}}%
977
978
979 \NewDocumentEnvironment{physicsproblem*}{ m }{%
     \newpage%
980
     \section*{#1}%
981
     \newlist{parts}{enumerate*}{2}%
982
     \setlist[parts]{label=\bfseries(\alph*)}}%
983
985 \NewDocumentCommand{\problempart}{}{\item}%
    An environment for problem solutions.
986 \NewDocumentEnvironment{physicssolution}{ +b }{%
     % Make equation numbering consecutive through the document.
     \begin{align}
988
       #1
989
     \end{align}
```

990

```
991 }{}%
992 \NewDocumentEnvironment{physicssolution*}{ +b }{%
      % Make equation numbering consecutive through the document.
994
      \begin{align*}
        #1
995
996
      \end{align*}
997 }{}%
     A simplified command for importing images.
998 \NewDocumentCommand{\image}{ O{scale=1} m m m }{%
      \begin{figure}[ht!]
999
        \begin{center}%
1000
          \includegraphics[#1]{#2}%
1001
        \end{center}%
1002
        \caption{#3}%
1003
        \label{#4}%
1004
1005
      \end{figure}%
1006 }%
     See https://tex.stackexchange.com/q/570223/218142.
1007 \NewDocumentCommand{\reason}{ O{4cm} m }
      {&&\begin{minipage}{#1}\raggedright\small #2\end{minipage}}
     Commands for scientific notation.
1009 \NewDocumentCommand{\tento}{ m }{\current{10^{#1}}}
1010 \NewDocumentCommand{\timestento}{ m }{\ensuremath{\;\times\;\tento{#1}}}
1011 \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.
1012 \newcounter{tikzhighlightnode}
1013 \NewDocumentCommand{\hilite}{ O{magenta!60} m O{rectangle} }{%
      \stepcounter{tikzhighlightnode}%
      \tikzmarknode{highlighted-node-\number\value{tikzhighlightnode}}{#2}%
1015
      \edef\temp{%
1016
        \noexpand\AddToShipoutPictureBG{%
1017
          \noexpand\begin{tikzpicture}[overlay,remember picture]%
1018
          \noexpand\iftikzmarkoncurrentpage{highlighted-node-\number\value{tikzhighlightnode}}}
1019
           \noexpand\node[inner sep=1.0pt,fill=#1,#3,fit=(highlighted-node-\number\value{tikzhighlightnode})]{};%
1020
1021
          \noexpand\fi
          \noexpand\end{tikzpicture}%
1022
        ጉ%
1023
1024
      }%
1025
      \temp%
1026 }%
     Intelligent slot command for coordinate-free tensor notation.
1027 \NewDocumentCommand{\slot}{ s d[] }{%
      % d[] must be used because of the way consecutive optional
1028
      \% arguments are handled. See xparse docs for details.
1029
      \IfBooleanTF{#1}
1030
```

```
1031
      {%
         \IfValueTF{#2}
1032
         {% Insert a vector, but don't show the slot.
1033
           \smash{\makebox[1.5em]{\ensuremath{#2}}}
1034
        }%
1035
1036
         {% No vector, no slot.
           \smash{\makebox[1.5em]{\ensuremath{}}}
1037
        }%
1038
      }%
1039
      {%
1040
         \IfValueTF{#2}
1041
        {% Insert a vector and show the slot.
1042
           \underline{\smash{\makebox[1.5em]{\ensuremath{#2}}}}
1043
1044
        {% No vector; just show the slot.
1045
           \underline{\smash{\makebox[1.5em]{\ensuremath{}}}}
1046
1047
        }%
1048
      }%
1049 }%
     Intelligent notation for contraction on pairs of slots.
1050 \NewDocumentCommand{\contraction}{ s m }{\%
      \IfBooleanTF{#1}
1051
      {\mathbf C}^{C}
1052
      {\symbb{C}}%
1053
1054 _{#2}
1055 }%
     Intelligent differential (exterior derivative) operator.
1056 \NewDocumentCommand{\diff}{ s }{%
      \mathbf{mathop}{}\!
1057
1058
      \IfBooleanTF{#1}
1059
      {\symbfsfup{d}}%
1060
      {\symsfup{d}}%
1061 }%
     Command to typeset tensor valence.
1062 \NewDocumentCommand{\valence}{ s m m }{\%}
      \IfBooleanTF{#1}
1063
        {(#2,#3)}
1064
1065
         {\binom{#2}{#3}}
```

1066 }%

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