# The mandi Bundle

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# Acknowledgements

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

I also acknowledge the LATEX developers who inhabit the TEX StackExchange site. Entering a new culture is daunting for anyone, especially for newcomers. The LATEX development culture is no exception. We all share a passion for creating beautiful documents and I have learned much over the past year that improved my ability to do just that. There are too many of you to list individually, and I would surely accidentally omit some were I to try. Collectively, I thank you all for your patience and advice.

# Change History

v3.0.0m General: Initial release. . . . . . . . . . . . . 6, 54, 80

List	of GlowScript Programs	
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$\begin{array}{c} 1 \\ 2 \end{array}$	Image shown 20 percent actual size	

# 1 Introduction

The mandi<sup>1</sup> bundle consists of three packages: mandi, mandistudent, and mandiexp. Package mandi<sup> $\rightarrow$ P.8</sup> provides the core functionality, namely correctly typesetting physical quantities and constants with their correct SI units as either scalars or vectors, depending on which is appropriate. Package mandistudent<sup> $\rightarrow$ P.54</sup> provides other typesetting capability appropriate for written problem solutions. Finally, package mandiexp<sup> $\rightarrow$ P.80</sup> provides commands for typesetting expressions from *Matter & Interactions*<sup>2</sup>

<sup>&</sup>lt;sup>1</sup>The bundle name can be pronounced either with two syllables, to rhyme with candy, or with three syllables, as M and I.

 $<sup>^2 \</sup>mathrm{See}\ \mathit{Matter}\ \mathcal{C}\ \mathit{Interactions}\ \mathrm{and}\ \mathrm{https://matter and interactions.org/}\ \mathrm{for}\ \mathrm{details}.$ 

# 2 Student/Instructor Quick Guide

Use  $\ensuremath{\mbox{$\backslash$}}^{P.54}$  to typeset the symbol for a vector. Use  $\ensuremath{\mbox{$\backslash$}}^{P.57}$  to typeset the symbol for a vector's direction. Use  $\ensuremath{\mbox{$\backslash$}}^{P.55}$  to typeset the symbol for the change in a vector or scalar. Use  $\ensuremath{\mbox{$\backslash$}}^{P.54}$  to typeset the zero vector. Use  $\ensuremath{\mbox{$\backslash$}}^{P.56}$  to typeset scientific notation.

Use a physical quantity's  $^{P.9}$  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  $^{P.9}$  and its variants.

Use a physical constant's  $^{P.25}$  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  $^{P.33}$  and its variant.

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

Use  $\mbox{\mbox{$\backslash$}} P.37$  to typeset symbolic vectors with components. Use the aliases  $\mbox{\mbox{$\backslash$}} P.55$  or  $\mbox{\mbox{$\backslash$}} P.55$  to typeset a direction or unit vector.

Use  $physicsproblem^{\to P.57}$  and  $parts^{\to P.57}$  and  $problempart^{\to P.58}$  for problems. For step-by-step mathematical solutions use  $physicssolution^{\to P.59}$ . Use  $glowscriptblock^{\to P.64}$  to typeset GlowScript programs. Use  $physicssolution^{\to P.67}$  to typeset programs files.

# 3 The mandi 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 v3.0.0m dated 2021-06-13 and is a stable build.

# 3.1 Package Options

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

```
	ext{units} = \langle type \ of \ unit \rangle
	ext{preciseconstants} = \langle boolean \rangle
```

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

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

# 3.2 The mandisetup Command

N 2021-02-17

## $\mbox{\mbox{\tt mandisetup}}\{\langle options \rangle\}$

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}

\mandisetup{preciseconstants}

\mandisetup{preciseconstants=false}

# 3.3 Physical Quantities

# 3.3.1 Typesetting Physical Quantities

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

N 2021-02-24

```
\label{eq:local_momentum} $$\operatorname{magnitude}$ $$\operatorname{constant}_{\langle c_1,\ldots,c_n\rangle}$$ $$\operatorname{constant}_{\langle c_1,\ldots,c_n\rangle}$
```

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

```
5 \,\mathrm{kg} \cdot \mathrm{m/s}
                                                                                            5 \,\mathrm{kg}\cdot\mathrm{m}\cdot\mathrm{s}^{-1}
\( \momentum{5} \)
                                                                                            5 \,\mathrm{kg} \cdot \mathrm{m/s}
\(\momentumvalue{5}\)
                                                                                            5 \,\mathrm{kg} \cdot \mathrm{m/s}
\(\momentumbaseunits{5}\)
\(\momentumderivedunits{5}\)
                                                                                            \langle 2, 3, 4 \rangle \,\mathrm{kg \cdot m/s}
\(\momentumalternateunits{5}\)
                                                                                            \langle 2, 3, 4 \rangle \,\mathrm{kg} \cdot \mathrm{m/s}
\(\momentumvector{2,3,4}\)
                                                                                            \langle 2, 3, 4 \rangle \,\mathrm{kg} \cdot \mathrm{m/s}
kg \cdot m \cdot s^{-1}
\(\momentumonlybaseunits\)
                                                                                            kg \cdot m/s
\(\momentumonlyderivedunits\)
                                                                                            kg \cdot m/s
\(\momentumonlyalternateunits\)
                                                                                            \langle 2, 3, 4 \rangle
\(\momentumvectorvalue{2,3,4}\)
\(\vectormomentumvalue{2,3,4}\)
                                                                                            \langle 2, 3, 4 \rangle
\(\momentumvectorbaseunits{2,3,4}\)
                                                                                            \langle 2, 3, 4 \rangle \,\mathrm{kg} \cdot \mathrm{m} \cdot \mathrm{s}^{-1}
\(\vectormomentumbaseunits{2,3,4}\)
                                                                                            \langle 2, 3, 4 \rangle \,\mathrm{kg} \cdot \mathrm{m} \cdot \mathrm{s}^{-1}
\(\momentumvectorderivedunits{2,3,4}\)
                                                                                            \langle 2, 3, 4 \rangle \, \text{kg} \cdot \text{m/s}
\(\vectormomentumderivedunits{2,3,4}\)
\(\momentumvectoralternateunits{2,3,4}\)
                                                                                            \langle 2, 3, 4 \rangle \,\mathrm{kg \cdot m/s}
\(\vectormomentumalternateunits{2,3,4}\)
                                                                                            \langle 2, 3, 4 \rangle \,\mathrm{kg \cdot m/s}
\(\momentumvectoronlybaseunits\)
                                                                                            \langle 2, 3, 4 \rangle \, \mathrm{kg \cdot m/s}
\(\vectormomentumonlybaseunits\)
                                                                                            \mathrm{kg}\cdot\mathrm{m}\cdot\mathrm{s}^{-1}
\(\momentumvectoronlyderivedunits\)
                                                                                            \mathrm{kg}\cdot\mathrm{m}\cdot\mathrm{s}^{-1}
\(\vectormomentumonlyderivedunits\)
                                                               //
\(\momentumvectoronlyalternateunits\)
                                                                                            kg \cdot m/s
\(\vectormomentumonlyalternateunits\)
                                                                                            kg \cdot m/s
                                                                                            kg \cdot m/s
                                                                                            kg \cdot m/s
```

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

#### 3.3.2 Checking Physical Quantities

N 2021-02-16

```
\checkquantity\{\langle name \rangle\}
```

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

# 3.3.3 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 \(^{+}P.37\) instead.

N 2021-02-24

N 2021-02-24

```
\acceleration\{\langle magnitude \rangle\}
\accelerationvector\{\langle c_1, \dots, c_n \rangle\}
\vectoracceleration\{\langle c_1, \dots, c_n \rangle\}
             name
              \acceleration
                                  base
                                                                                                                                                                                       derived
                                                                                                                                                                                                                                                                                                                                           alternate
                                  \mathbf{m}\cdot\mathbf{s}^{-2}
                                                                                                                                                                                                                                                                                                                                           m/s^2
                                                                                                                                                                                       N/kg
\adjustledge \adjustlegge \ad
             name
              \amount
                                  base
                                                                                                                                                                                       derived
                                                                                                                                                                                                                                                                                                                                           alternate
                                  mol
                                                                                                                                                                                       mol
                                                                                                                                                                                                                                                                                                                                           mol
\agnitude \
\angularaccelerationvector\{\langle c_1, \dots, c_n \rangle\}
\vectorangularacceleration\{\langle c_1, \dots, c_n \rangle\}
             name
              \angularacceleration
                                 base
                                                                                                                                                                                       derived
                                                                                                                                                                                                                                                                                                                                           alternate
                                  \rm rad\cdot s^{-2}
                                                                                                                                                                                       rad/s^2
                                                                                                                                                                                                                                                                                                                                           rad/s^2
\agnitude \
             name
              \angularfrequency
                                                                                                                                                                                       derived
                                                                                                                                                                                                                                                                                                                                           alternate
                                  \rm rad\cdot s^{-1}
                                                                                                                                                                                       rad/s
                                                                                                                                                                                                                                                                                                                                           rad/s
```

```
\agnitude \
N 2021-02-24
                                                             \angularimpulsevector\{\langle c_1, \dots, c_n \rangle\}
                                                             \{\langle c_1, \dots, c_n \rangle\}
                                                                       name
                                                                       \angularimpulse
                                                                                     base
                                                                                                                                                                                               derived
                                                                                                                                                                                                                                                                                                          alternate
                                                                                      \mathrm{kg}\cdot\mathrm{m}^2\cdot\mathrm{s}^{-1}
                                                                                                                                                                                                kg \cdot m^2/s
                                                                                                                                                                                                                                                                                                          kg \cdot m^2/s
                                                             \agnitude \
N 2021-02-24
                                                             \aggreent \agg
                                                             \colonerright{f ar vectorangular momentum}\{\langle c_1,\ldots,c_n
angle\}
                                                                       name
                                                                       \angularmomentum
                                                                                     base
                                                                                                                                                                                               derived
                                                                                                                                                                                                                                                                                                          alternate
                                                                                     \mathrm{kg}\cdot\mathrm{m}^2\cdot\mathrm{s}^{-1}
                                                                                                                                                                                                kg \cdot m^2/s
                                                                                                                                                                                                                                                                                                          kg \cdot m^2/s
                                                             \agnitude \
N 2021-02-24
                                                             \aggreent \operatorname{\belowder} \{\langle c_1, \dots, c_n \rangle\}
                                                             \c
                                                                      name
                                                                       \angularvelocity
                                                                                     base
                                                                                                                                                                                                derived
                                                                                                                                                                                                                                                                                                          alternate
                                                                                      \rm rad\cdot s^{-1}
                                                                                                                                                                                                rad/s
                                                                                                                                                                                                                                                                                                          rad/s
                                                             \area{\langle magnitude \rangle}
                                                                      name
                                                                       \area
                                                                                      base
                                                                                                                                                                                                derived
                                                                                                                                                                                                                                                                                                          alternate
                                                                                      \mathrm{m}^2
                                                                                                                                                                                                m^2
                                                                                                                                                                                                                                                                                                          \mathrm{m}^2
                                                             \arrange density {\langle magnitude \rangle}
                                                                       name
                                                                       \areachargedensity
                                                                                      base
                                                                                                                                                                                                derived
                                                                                                                                                                                                                                                                                                          alternate
                                                                                      {\rm A\cdot s\cdot m^{-2}}
                                                                                                                                                                                                C/m^2
                                                                                                                                                                                                                                                                                                          C/m^2
                                                             \areamassdensity{\langle magnitude \rangle}
                                                                       name
                                                                       \areamassdensity
                                                                                                                                                                                                derived
                                                                                      base
                                                                                                                                                                                                                                                                                                          alternate
```

 $kg/m^2$ 

 ${\rm kg/m^2}$ 

 $\rm kg\cdot m^{-2}$ 

```
\colone{capacitance} {magnitude}
    name
    \capacitance
         base
                                                    derived
                                                                                              alternate
         A^2 \cdot s^4 \cdot kg^{-1} \cdot m^{-2}
                                                                                              C/V
name
    \charge
                                                    derived
          base
                                                                                              alternate
          A \cdot s
\colonerrel{cmagneticfield} \colonerrel{cmagneticfield} \colonerrel{cmagneticfield}
\cmagneticfieldvector\{\langle c_1, \dots, c_n \rangle\}
\verb|\vectorcmagneticfield{|\langle c_1, \dots, c_n \rangle|}
    name
    \verb|\cmagneticfield|
         \mathbf{base}
                                                    derived
                                                                                              alternate
         \mathrm{kg}\cdot\mathrm{m}\cdot\mathrm{A}^{-1}\cdot\mathrm{s}^{-3}
                                                    N/C
                                                                                              N/C
\conductance{\langle magnitude \rangle}
    name
    \conductance
                                                    derived
                                                                                              alternate
         \mathbf{base}
         A^2 \cdot s^3 \cdot kg^{-1} \cdot m^{-2}
                                                    \mathbf{S}
                                                                                              A/V
\conductivity{\langle magnitude \rangle}
    name
    \conductivity
                                                    derived
         base
                                                                                              alternate
         A^2 \cdot s^3 \cdot kg^{-1} \cdot m^{-3}
                                                                                              A/V \cdot m
                                                    S/m
\conventional current {\langle magnitude \rangle}
   name
    \conventionalcurrent
```

N 2021-02-24

base

A

alternate

derived

 $\mathrm{C/s}$ 

```
\current
                                                                                                 base
                                                                                                                                                                                                                       derived
                                                                                                                                                                                                                                                                                                                                             alternate
                                                                                                 Α
                                                                      \currentdensity\{\langle magnitude \rangle\}
                                                                      \currentdensityvector\{\langle c_1, \dots, c_n \rangle\}
N 2021-02-24
                                                                      \vectorcurrentdensity\{\langle c_1, \dots, c_n \rangle\}
                                                                                 name
                                                                                 \currentdensity
                                                                                                 base
                                                                                                                                                                                                                       derived
                                                                                                                                                                                                                                                                                                                                             alternate
                                                                                                 {\rm A\cdot m^{-2}}
                                                                                                                                                                                                                       C/s \cdot m^2
                                                                                                                                                                                                                                                                                                                                              A/m^2
                                                                      \dielectricconstant{\langle magnitude \rangle}
                                                                                 name
                                                                                 \dielectricconstant
                                                                                                 base
                                                                                                                                                                                                                        derived
                                                                                                                                                                                                                                                                                                                                             alternate
                                                                      \displacement{\langle magnitude \rangle}
                                                                      \displacementvector\{\langle c_1, \dots, c_n \rangle\}
  N 2021-02-24
                                                                      \colone{1cm} \co
                                                                                 name
                                                                                 \displacement
                                                                                                 base
                                                                                                                                                                                                                        derived
                                                                                                                                                                                                                                                                                                                                             alternate
                                                                                                 m
                                                                                                                                                                                                                        m
                                                                                                                                                                                                                                                                                                                                             _{\mathrm{m}}
                                                                      \delta constant (magnitude)
                                                                                 name
                                                                                 \duration
                                                                                                 base
                                                                                                                                                                                                                        derived
                                                                                                                                                                                                                                                                                                                                             alternate
                                                                      \ensuremath{\mbox{\mbox{electricdipolemoment}}} \langle magnitude \rangle \}
  N 2021-02-24
                                                                      \electricdipolemomentvector\{\langle c_1,\ldots,c_n
angle\}
                                                                      \verb|\vectorelectricdipolemoment| \{\langle c_1, \dots, c_n \rangle\}|
                                                                                 name
                                                                                 \electricdipolemoment
                                                                                                                                                                                                                       derived
                                                                                                                                                                                                                                                                                                                                             alternate
                                                                                                 base
                                                                                                 A\cdot s\cdot m
                                                                                                                                                                                                                       \mathbf{C}\cdot\mathbf{m}
                                                                                                                                                                                                                                                                                                                                             \mathbf{C}\cdot\mathbf{m}
```

```
N 2021-02-24
```

N 2021-05-01

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

```
\ensuremath{\mbox{\mbox{\bf dectricfield}}} \langle magnitude \rangle \}
\electricfieldvector\{\langle c_1, \dots, c_n \rangle\}
\vectorelectricfield\{\langle c_1, \dots, c_n \rangle\}
    name
    \electricfield
           \mathbf{base}
                                                              derived
                                                                                                                 alternate
           kg\cdot m\cdot A^{-1}\cdot s^{-3}
                                                              V/m
                                                                                                                 N/C
\ensuremath{\mbox{\mbox{\bf lectricflux}}} \langle magnitude \rangle \}
    name
    \electricflux
           base
                                                              derived
                                                                                                                 alternate
           \mathrm{kg}\cdot\mathrm{m}^{3}\cdot\mathrm{A}^{-1}\cdot\mathrm{s}^{-3}
                                                              V \cdot m
                                                                                                                 N \cdot m^2/C
\ensuremath{\mbox{\mbox{electric}potential}} \{\langle magnitude \rangle\}
    name
    \electricpotential
           base
                                                              derived
                                                                                                                 alternate
           \mathrm{kg}\cdot\mathrm{m}^2\cdot\mathrm{A}^{-1}\cdot\mathrm{s}^{-3}
\ensuremath{\mbox{\mbox{\mbox{$\sim$}}}}
    name
    \verb|\electric potential difference|
                                                                                                                 alternate
           \mathbf{base}
                                                              derived
           \mathrm{kg}\cdot\mathrm{m}^2\cdot\mathrm{A}^{-1}\cdot\mathrm{s}^{-3}
\ensuremath{\mbox{\mbox{$\backslash$}}} (an a gnitude)
    name
    \electroncurrent
           base
                                                              derived
                                                                                                                 alternate
           \mathrm{s}^{-1}
                                                              e/s
                                                                                                                 e/s
\ensuremath{\mbox{\sf lemf}} \{\langle magnitude \rangle \}
    name
    \emf
           base
                                                              derived
                                                                                                                 alternate
           \mathrm{kg}\cdot\mathrm{m}^2\cdot\mathrm{A}^{-1}\cdot\mathrm{s}^{-3}
                                                              V
```

name \energy derived basealternate  $\mathrm{kg}\cdot\mathrm{m}^2\cdot\mathrm{s}^{-2}$ N 2021-04-15  $\ensuremath{\mbox{\mbox{\mbox{$\sim$}}}} \ensuremath{\mbox{\mbox{\mbox{$\sim$}}}} \ensuremath{\mbox{\mbox{$\sim$}}} \ensuremath{\mbox{\mbox{$\sim$}}} \ensuremath{\mbox{\mbox{$\sim$}}} \ensuremath{\mbox{$\sim$}} \en$ name \energyinev base derived alternate eV ${
m eV}$  ${
m eV}$ N 2021-04-15  $\ensuremath{\mbox{\mbox{\mbox{$\sim$}}}} \ensuremath{\mbox{\mbox{\mbox{$\sim$}}}} \ensuremath{\mbox{\mbox{\mbox{$\sim$}}}} \ensuremath{\mbox{\mbox{$\sim$}}} \ensuremath{\mbox{\mbox{$\sim$}}} \ensuremath{\mbox{\mbox{$\sim$}}} \ensuremath{\mbox{\mbox{$\sim$}}} \ensuremath{\mbox{\mbox{$\sim$}}} \ensuremath{\mbox{\mbox{$\sim$}}} \ensuremath{\mbox{$\sim$}} \ensuremath{\mbox{\mbox{$\sim$}}} \ensuremath{\mbox{\mbox{$\sim$}}} \ensuremath{\mbox{\mbox{$\sim$}}} \ensuremath{\mbox{\mbox{$\sim$}}} \ensuremath{\mbox{\mbox{$\sim$}}} \ensuremath{\mbox{\mbox{$\sim$}}} \ensuremath{\mbox{$\sim$}} \ensuremath{\mbox{$\sim$}$ name \energyinkev base derived alternate keVkeVkeVN 2021-04-15  $\ensuremath{\mbox{\mbox{\mbox{$\sim$}}}} \ensuremath{\mbox{\mbox{\mbox{$\sim$}}}} \ensuremath{\mbox{\mbox{$\sim$}}} \ensuremath{\mbox{\mbox{$\sim$}}} \ensuremath{\mbox{\mbox{$\sim$}}} \ensuremath{\mbox{$\sim$}} \en$ name \energyinmev derived  ${\bf base}$ alternateMeVMeVMeV $\ensuremath{\mbox{\tt denergydensity}} \{\langle magnitude \rangle\}$ name \energydensity  $\mathbf{base}$ derived alternate  $\mathrm{kg}\cdot\mathrm{m}^{-1}\cdot\mathrm{s}^{-2}$  $J/m^3$  $J/m^3$  $\ensuremath{\mbox{\mbox{energyflux}}} \langle magnitude \rangle \}$ N 2021-02-24 \energyfluxvector $\{\langle c_1, \dots, c_n \rangle\}$  $\colone{1.5}$ name \energyflux base derived alternate  $\rm kg\cdot s^{-3}$  $W/m^2$  $W/m^2$  $\ensuremath{\mbox{\mbox{entropy}}} \langle magnitude \rangle \}$ name \entropy

alternate

J/K

derived

J/K

base

 $\mathrm{kg}\cdot\mathrm{m}^2\cdot\mathrm{s}^{-2}\cdot\mathrm{K}^{-1}$ 

```
\force{\langle magnitude \rangle}
N 2021-02-24
                     \forcevector\{\langle c_1, \dots, c_n \rangle\}
                     name
                        \force
                                                                  derived
                             base
                                                                                                      alternate
                             \rm kg\cdot m\cdot s^{-2}
                     name
                        \frequency
                                                                  derived
                                                                                                      alternate
                             base
                             {f s}^{-1}
                     \gravitationalfield{\langle magnitude \rangle}
N 2021-02-24
                     \gravitationalfieldvector\{\langle c_1, \dots, c_n \rangle\}
                     \ensuremath{\left\langle vectorgravitationalfield \{\langle c_1,\dots,c_n \rangle\}}
                        name
                        \gravitationalfield
                             \mathbf{base}
                                                                  derived
                                                                                                      alternate
                             \mathbf{m}\cdot\mathbf{s}^{-2}
                                                                  N/kg
                                                                                                      N/kg
                     \gravitationalpotential{\langle magnitude \rangle}
                        name
                        \gravitationalpotential
                             base
                                                                  derived
                                                                                                      alternate
                             \mathrm{m}^2\cdot\mathrm{s}^{-2}
                                                                  J/kg
                                                                                                      J/kg
                     \gravitational potential difference {\langle magnitude \rangle}
N 2021-05-01
                        name
                         \gravitationalpotentialdifference
                             base
                                                                  derived
                                                                                                      alternate
                             \rm m^2\cdot s^{-2}
                                                                  J/kg
                                                                                                      J/kg
                     \ightharpoonup
N 2021-02-24
                     \impulsevector\{\langle c_1, \dots, c_n \rangle\}
                     \vectorimpulse\{\langle c_1, \dots, c_n 
angle\}
                        name
                        \impulse
                                                                  derived
                             base
                                                                                                      alternate
```

 $N\cdot s$ 

 $N \cdot s$ 

 $\rm kg\cdot m\cdot s^{-1}$ 

 $\label{limits} \$ name \indexofrefraction base derived alternate name \inductance base derived alternate  $kg\cdot m^2\cdot A^{-2}\cdot s^{-2}$  $V\cdot s/A$  $\label{linearchargedensity} \{\langle magnitude \rangle\}$ name *\linearchargedensity* basederived alternate  $A\cdot s\cdot m^{-1}$ C/mC/m $\label{linearmassdensity} $$ \limearmassdensity {\langle magnitude \rangle}$$ name \linearmassdensity base derived alternate  $\rm kg\cdot m^{-1}$ kg/mkg/m**\luminousintensity** $\{\langle magnitude \rangle\}$ name \luminousintensity derived alternate base  $\operatorname{cd}$  $\operatorname{cd}$  $\operatorname{cd}$  $\mbox{\mbox{\tt magneticcharge}} \{ \langle magnitude \rangle \}$ name \magneticcharge alternate base derived  $\mathbf{A}\cdot\mathbf{m}$  $A \cdot m$  $\mathbf{A}\cdot\mathbf{m}$  $\mbox{\t \mbox{\tt magnetic dipole moment \t \c \c \c }} \langle c_1, \dots, c_n 
angle \}$ 

U 2021-05-02

N 2021-02-24

 $\colone{1cm} \colone{1cm} \co$ 

\magneticdipolemoment

derived base alternate  $\mathbf{A}\cdot\mathbf{m}^2$  $A\cdot m^2$ J/T

N 2021-02-24

```
\verb|\magneticfieldvector| \{\langle c_1, \dots, c_n \rangle\}|
\vectormagneticfield\{\langle c_1, \dots, c_n \rangle\}
```

alternate

name

\magneticfield

base derived alternate  $\mathrm{kg}\cdot\mathrm{A}^{-1}\cdot\mathrm{s}^{-2}$  $N/A \cdot m$ 

 $\mbox{\mbox{\tt magneticflux}} \langle magnitude \rangle \}$ 

name

\magneticflux

 ${\bf base}$ derived alternate  $\mathrm{kg}\cdot\mathrm{m}^2\cdot\mathrm{A}^{-1}\cdot\mathrm{s}^{-2}$  $T\cdot m^2$  $V \cdot s$ 

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

name \mass

> derived base

kg kgkg

 $\mbox{\mbox{$\mbox{mobility}}{\mbox{$\mbox{}\mbox{$\mbox$ 

name

\mobility

base derived alternate  $\mathrm{kg}\cdot\mathrm{m}^2\cdot\mathrm{A}^{-1}\cdot\mathrm{s}^{-4}$  $m^2/V\cdot s$  $C\cdot m/N\cdot s$ 

 $\mbox{\colored}(magnitude)$ 

name

N 2021-02-24

\momentofinertia

derived alternate  $J \cdot s^2$  $kg\cdot m^2$  $kg\cdot m^2$ 

 $\mbox{\constraint} {\mbox{\constraint}} {\mbox{\c$ 

\momentumvector $\{\langle c_1,\ldots,c_n\rangle\}$ 

 $\colone{1.5} \colone{1.5} \co$ 

\momentum

 $\begin{array}{ccc} \textbf{base} & \textbf{derived} & \textbf{alternate} \\ \text{kg} \cdot \text{m} \cdot \text{s}^{-1} & \text{kg} \cdot \text{m/s} & \text{kg} \cdot \text{m/s} \end{array}$ 

 $\mbox{\verb||momentumflux||} \langle magnitude \rangle \}$ 

 $\verb| momentumfluxvector} \{\langle c_1, \dots, c_n \rangle \}$ 

\vectormomentumflux $\{\langle c_1, \dots, c_n \rangle\}$ 

name

N 2021-02-24

\momentumflux

 $\begin{array}{lll} \text{base} & \text{derived} & \text{alternate} \\ \text{kg} \cdot \text{m}^{-1} \cdot \text{s}^{-2} & \text{N/m}^2 & \text{N/m}^2 \end{array}$ 

 $\noindent \operatorname{numberdensity} \{\langle magnitude \rangle\}$ 

name

\numberdensity

 $\begin{array}{ccc} \textbf{base} & & \textbf{derived} & & \textbf{alternate} \\ m^{-3} & & /m^3 & & /m^3 \end{array}$ 

name

\permeability

 $\begin{array}{lll} \text{base} & \text{derived} & \text{alternate} \\ \text{kg} \cdot m \cdot A^{-2} \cdot s^{-2} & \text{H/m} & \text{T} \cdot m/A \end{array}$ 

 $\protect\operatorname{\mathtt{ar{permittivity}}} \langle magnitude \rangle \}$ 

name

\permittivity

 $\begin{array}{ccc} \textbf{base} & \textbf{derived} & \textbf{alternate} \\ A^2 \cdot s^4 \cdot kg^{-1} \cdot m^{-3} & F/m & C^2/N \cdot m^2 \end{array}$ 

\planeangle{ $\langle magnitude \rangle$ }

name

\planeangle

 $\begin{array}{lll} \text{base} & \text{derived} & \text{alternate} \\ m \cdot m^{-1} & \mathrm{rad} & \mathrm{rad} \end{array}$ 

 $\polarizability{\langle magnitude \rangle}$ 

name

\polarizability

 $\begin{array}{ccc} \textbf{base} & \textbf{derived} & \textbf{alternate} \\ A^2 \cdot s^4 \cdot kg^{-1} & C \cdot m^2/V & C^2 \cdot m/N \end{array}$ 

```
\operatorname{\mathtt{ower}}\{\langle magnitude \rangle\}
   name
   \power
        base
                                            derived
                                                                                 alternate
        \mathrm{kg}\cdot\mathrm{m}^2\cdot\mathrm{s}^{-3}
                                                                                 J/s
\operatorname{poynting}\{\langle magnitude \rangle\}
\operatorname{\texttt{ighthap{poyntingvector}}}\{\langle c_1, \dots, c_n 
angle \}
\vectorpoynting\{\langle c_1, \dots, c_n \rangle\}
   name
   \poynting
                                             derived
        base
                                                                                 alternate
        \rm kg\cdot s^{-3}
                                            W/m^2
                                                                                 W/m^2
\pressure{\langle magnitude \rangle}
   name
   \pressure
        base
                                            derived
                                                                                 alternate
        \mathrm{kg}\cdot\mathrm{m}^{-1}\cdot\mathrm{s}^{-2}
                                            Pa
                                                                                 N/m^2
name
   \relativepermeability
                                                                                 alternate
        base
                                            derived
name
   \relativepermittivity
                                            derived
                                                                                 alternate
        \mathbf{base}
name
   \resistance
                                            derived
        base
                                                                                 alternate
        \mathrm{kg}\cdot\mathrm{m}^2\cdot\mathrm{A}^{-2}\cdot\mathrm{s}^{-3}
                                            Ω
```

N 2021-02-24

\resistivity

derived base alternate  $\mathrm{kg}\cdot\mathrm{m}^{3}\cdot\mathrm{A}^{-2}\cdot\mathrm{s}^{-3}$  $\Omega \cdot m$  $V \cdot m/A$ 

name

\solidangle

 $\mathbf{base}$ derived alternate  $\mathrm{m}^2\cdot\mathrm{m}^{-2}$  $\operatorname{sr}$ 

 $\specificheatcapacity{\langle magnitude \rangle}$ 

name

\specificheatcapacity

derived base alternate  $\mathbf{m}^2 \cdot \mathbf{s}^{-2} \cdot \mathbf{K}^{-1}$  $J/K \cdot kg$  $J/K \cdot kg$ 

 $\springstiffness{\langle magnitude \rangle}$ 

name

\springstiffness

 $\mathbf{base}$ derived alternate  $\rm kg\cdot s^{-2}$ N/mN/m

 $\springstretch{\langle magnitude \rangle}$ 

name

\springstretch

base derived alternate m

name

\stress

basederived alternate  $\mathrm{kg}\cdot\mathrm{m}^{-1}\cdot\mathrm{s}^{-2}$ Pa  $\rm N/m^2$ 

name

\strain

base derived alternate

```
\texttt{\temperature}\{\langle magnitude \rangle\}
                            name
                            \temperature
                                  base
                                                                            derived
                                                                                                                      alternate
                                  Κ
                                                                            Κ
                                                                                                                      Κ
                        \texttt{\text{torque}}\{\langle magnitude \rangle\}
                        \torquevector\{\langle c_1, \dots, c_n \rangle\}
N 2021-02-24
                        \vectortorque\{\langle c_1, \dots, c_n \rangle\}
                            name
                            \torque
                                                                            derived
                                  base
                                                                                                                      alternate
                                  \mathrm{kg}\cdot\mathrm{m}^2\cdot\mathrm{s}^{-2}
                                                                            N\cdot m
                                                                                                                      N \cdot m
                        \ensuremath{\mbox{velocity}}\{\langle magnitude \rangle\}
                        \ensuremath{lack}
N 2021-02-24
                         \vectorvelocity\{\langle c_1, \dots, c_n \rangle\}
                        \ensuremath{\mbox{velocityc}} \{\langle magnitude \rangle\}
N 2021-02-24
                        \velocitycvector\{\langle c_1, \dots, c_n 
angle\}
                        \vectorvelocityc\{\langle c_1, \dots, c_n 
angle\}
                            name
                            \velocity
                                                                            derived
                                  base
                                                                                                                      alternate
                                  \mathbf{m}\cdot\mathbf{s}^{-1}
                                                                            m/s
                                                                                                                      m/s
                            name
                            \velocityc
                                  base
                                                                            derived
                                                                                                                      alternate
                                                                            \mathbf{c}
                        name
                            \volume
                                                                            derived
                                  base
                                                                                                                      alternate
                                  \mathrm{m}^3
                                                                            \mathrm{m}^3
                                                                                                                      \mathrm{m}^3
                        \volume charge density {\langle magnitude \rangle}
                            name
                            \volumechargedensity
                                                                            derived
                                                                                                                      alternate
                                  base
                                  {
m A\cdot s/m^{-3}}
                                                                            C/m^3
                                                                                                                      C/m^3
```

```
\vert volume mass density \{\langle magnitude \rangle\}
              name
               \volumemassdensity
                                                                                                                                                                                             derived
                                   base
                                                                                                                                                                                                                                                                                                                                                     alternate
                                   \mathrm{kg}\cdot\mathrm{m}^{-3}
                                                                                                                                                                                             kg/m^3
                                                                                                                                                                                                                                                                                                                                                     kg/m^3
\mathbf{wavelength}\{\langle magnitude \rangle\}
              name
              \wavelength
                                  base
                                                                                                                                                                                             derived
                                                                                                                                                                                                                                                                                                                                                     alternate
                                   m
\wedge wavenumber {\langle magnitude \rangle}
\wavenumbervector\{\langle c_1, \dots, c_n \rangle\}
\vectorwavenumber\{\langle c_1, \dots, c_n \rangle\}
              name
               \wavenumber
                                   base
                                                                                                                                                                                             derived
                                                                                                                                                                                                                                                                                                                                                     alternate
                                  \mathrm{m}^{-1}
                                                                                                                                                                                             /m
                                                                                                                                                                                                                                                                                                                                                      /m
\mathbf{\work}\{\langle magnitude \rangle\}
              name
               \work
                                   base
                                                                                                                                                                                             derived
                                                                                                                                                                                                                                                                                                                                                     alternate
                                  \mathrm{kg}\cdot\mathrm{m}^2\cdot\mathrm{s}^{-2}
                                                                                                                                                                                             J
                                                                                                                                                                                                                                                                                                                                                     J
\widtharpoonup \wid
              name
               \youngsmodulus
                                   base
                                                                                                                                                                                             derived
                                                                                                                                                                                                                                                                                                                                                     alternate
```

# 3.3.4 Defining and Redefining Physical Quantities

Pa

 $\mathrm{kg}\cdot\mathrm{m}^{-1}\cdot\mathrm{s}^{-2}$ 

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

N 2021-02-24

```
\newscalarquantity{\langle name \rangle} {\langle base\ units \rangle} [\langle derived\ units \rangle] [\langle alternate\ units \rangle] } [\langle alternate\ units \rangle]
```

Command to (re)define 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 \newvectorquantity \times P.24 or \renewvectorquantity \times P.24 to (re)define a quantity.

 $N/m^2$ 

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

```
\newvectorquantity{\langle name \rangle}{\langle base\ units \rangle}[\langle derived\ units \rangle][\langle alternate\ units \rangle] \renewvectorquantity{\langle name \rangle}{\langle base\ units \rangle}[\langle derived\ units \rangle][\langle alternate\ units \rangle]
```

Command to (re)define 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 \newscalarquantity or \renewscalarquantity to (re)define a quantity.

# 3.3.5 Changing Units

Units are set when mandi is loaded, but the default setting can be easily overridden in four ways: command variants that are defined when a physical quantity P.9 or physical constant D.25 is defined, a global modal command (switch), a command that sets units for a single instance, and an environment that sets units for its duration. All of these methods work for both physical quantities and physical constants.

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
```

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

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

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

U 2021-02-26

**U** 2021-02-26

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

```
\( \momentum{5} \)
\( \oofpez \)
\begin{usebaseunits}
                                                                                 5 \,\mathrm{kg} \cdot \mathrm{m/s}
   \(\momentum{5}\)\\
                                                                                 9\times 10^9\,\mathrm{N\cdot m^2/C^2}
   \( \oofpez \)
                                                                                 5\,\mathrm{kg}\cdot\mathrm{m}\cdot\mathrm{s}^{-1}
\end{usebaseunits}
                                                                                 9\times10^9\,\mathrm{kg\cdot m^3\cdot A^{-2}\cdot s^{-4}}
\begin{usederivedunits}
   \(\momentum{5}\)\\
                                                                                 5 \,\mathrm{kg} \cdot \mathrm{m/s}
   \(\oofpez \)
                                                                                 9 \times 10^9 \,\mathrm{m/F}
\end{usederivedunits}
                                                                                 5 \, \mathrm{kg \cdot m/s}
\begin{usealternateunits}
                                                                                 9 \times 10^9 \,\mathrm{N} \cdot \mathrm{m}^2/\mathrm{C}^2
   \(\momentum{5}\)\\
   \(\oofpez\)
\end{usealternateunits}
```

# 3.4 Physical Constants

# 3.4.1 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
\(\oofpez\)
\(\oofpezapproximatevalue\)
                                                                                  8.9875517923 \times 10^9
\( \oofpezprecisevalue \)
\(\oofpezmathsymbol\)
                                                                                  9 \times 10^9 \,\mathrm{kg}\cdot\mathrm{m}^3\cdot\mathrm{A}^{-2}\cdot\mathrm{s}^{-4}
\(\oofpezbaseunits\)
\(\oofpezderivedunits\)
                                                                                  9 \times 10^{9} \, \text{m/F}
\(\oofpezalternateunits\)
                                                                                  9 \times 10^9 \, \mathrm{N} \cdot \mathrm{m}^2/\mathrm{C}^2
\( \oofpezonlybaseunits \)
                                                                                  \mathrm{kg}\cdot\mathrm{m}^{3}\cdot\mathrm{A}^{-2}\cdot\mathrm{s}^{-4}
\(\oofpezonlyderivedunits\)
\(\oofpezonlyalternateunits\)
                                                                                  m/F
                                                                                  N \cdot m^2/C^2
```

# 3.4.2 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.

## 3.4.3 Predefined Physical Constants

N 2021-02-02

N 2021-02-02

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 don't fret if the names used here vary from other sources. Here are all the physical constants, with all their units, defined in mandi. The constants \coulombconstant^{P.26} and \biotsavartconstant^{P.26} are defined as semantic aliases for, respectively, \oofpez^{P.30} and \mzofp^{P.29}.

\avogadro			(exact)
$egin{aligned} \mathbf{name} \\ \mathbf{vavogadro} \\ \mathbf{symbol} \\ \mathbf{N_A} \\ \mathbf{base} \\ \mathbf{mol}^{-1} \end{aligned}$	$\begin{array}{c} \textbf{approximate} \\ 6\times10^{23} \\ \textbf{derived} \\ /\mathrm{mol} \end{array}$	$\begin{array}{c} \textbf{precise} \\ 6.02214076 \times 10^{23} \\ \textbf{alternate} \\ / \text{mol} \end{array}$	
\biotsavartconstant			
$\begin{array}{c} \textbf{name} \\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \$	${f approximate} \ 10^{-7} \ {f derived} \ {f H/m}$	$egin{aligned} \mathbf{precise} \ 10^{-7} \ \mathbf{alternate} \ \mathbf{T}\cdot\mathbf{m}/\mathbf{A} \end{aligned}$	
\bohrradius			
name \bohrradius symbol ao base m	$\begin{array}{c} \textbf{approximate} \\ 5.3 \times 10^{-11} \\ \textbf{derived} \\ \mathbf{m} \end{array}$	$\begin{array}{c} \textbf{precise} \\ 5.29177210903 \times 10^{-11} \\ \textbf{alternate} \\ \mathbf{m} \end{array}$	
\boltzmann			(exact)
$\begin{array}{c} \textbf{name} \\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \$	$egin{aligned} \mathbf{approximate} \ 1.4  imes 10^{-23} \ \mathbf{derived} \ \mathrm{J/K} \end{aligned}$	$\begin{array}{c} \textbf{precise} \\ 1.380649 \times 10^{-23} \\ \textbf{alternate} \\ \text{J/K} \end{array}$	
\coulombconstant			

\coulombconstant

approximate symbolprecise

 $\frac{1}{4\pi\varepsilon_o}$  $9 \times 10^9$  $8.9875517923\times10^{9}$ 

base derived alternate $\mathrm{kg}\cdot\mathrm{m}^{3}\cdot\mathrm{A}^{-2}\cdot\mathrm{s}^{-4}$ m/F $N \cdot m^2/C^2$ 

# \earthmass

name

\earthmass

symbolapproximate precise  $6.0\times10^{24}$  $5.9722 \times 10^{24}$  $\rm M_{\rm Earth}$ base derived alternate kg

kg kg

## \earthmoondistance

name

\earthmoondistance

symbolapproximate precise  $3.8\times10^{8}$  $3.81550\times10^{8}$  $d_{\rm EM}$ base derived alternate

m  $_{\mathrm{m}}$ m

# \earthradius

name

\earthradius

symbol approximate precise  $6.4\times10^6$  $6.3781\times10^{6}$  $\mathrm{R}_{\mathrm{Earth}}$ base derived alternate

 $\mathbf{m}$ 

## \earthsundistance

name

\earthsundistance

symbolapproximate precise  $1.5\times10^{11}$  $1.496\times10^{11}$  $\mathrm{d}_{\mathrm{ES}}$ base derived alternate

 $\mathbf{m}$  $_{\mathrm{m}}$  $_{\mathrm{m}}$ 

# \electroncharge

\electroncharge

symbol approximate precise

 $q_{e} \qquad \qquad -1.6 \times 10^{-19} \qquad \qquad -1.602176634 \times 10^{-19}$ 

base derived alternate

 $A \cdot s$  C

\electronCharge

name

\electronCharge

symbol approximate precise

 $Q_{\rm e} \qquad \qquad -1.6 \times 10^{-19} \qquad \qquad -1.602176634 \times 10^{-19}$ 

base derived alternate

 $A \cdot s$  C

\electronmass

name

\electronmass

symbol approximate precise

 $m_{\rm e} \qquad \qquad 9.1 \times 10^{-31} \qquad \qquad 9.1093837015 \times 10^{-31}$ 

base derived alternate

kg kg

\elementarycharge (exact)

name

\elementarycharge

symbol approximate precise

e  $1.6 \times 10^{-19}$   $1.602176634 \times 10^{-19}$ 

base derived alternate

 $\mathbf{A}\cdot\mathbf{s} \qquad \qquad \mathbf{C}$ 

\finestructure

 $\mathbf{name}$ 

 $\finestructure$ 

 $symbol \hspace{1cm} approximate \hspace{1cm} precise$ 

 $\alpha \qquad \qquad \frac{1}{137} \qquad \qquad 7.2973525693 \times 10^{-3}$ 

base derived alternate

\hydrogenmass

\hydrogenmass

symbol approximate precise

 $\begin{array}{lll} m_H & 1.7\times 10^{-27} & 1.6737236\times 10^{-27} \\ \mbox{base} & \mbox{derived} & \mbox{alternate} \end{array}$ 

 ${\rm kg} \hspace{1cm} {\rm kg} \hspace{1cm} {\rm kg}$ 

\moonearthdistance

name

\moonearthdistance

 ${
m m}$   ${
m m}$ 

\moonmass

name

\moonmass

 $\begin{array}{lll} \text{symbol} & \text{approximate} & \text{precise} \\ M_{Moon} & 7.3 \times 10^{22} & 7.342 \times 10^{22} \\ \text{base} & \text{derived} & \text{alternate} \end{array}$ 

kg kg

\moonradius

name

\moonradius

 $\begin{array}{lll} \text{symbol} & \text{approximate} & \text{precise} \\ R_{Moon} & 1.7 \times 10^6 & 1.7371 \times 10^6 \\ \text{base} & \text{derived} & \text{alternate} \end{array}$ 

 $m \hspace{1.5cm} m \hspace{1.5cm} m$ 

\mzofp

name

\mzofp

 $\begin{array}{lll} \text{symbol} & \text{approximate} & \text{precise} \\ \frac{\mu_0}{4\pi} & 10^{-7} & 10^{-7} \\ \text{base} & \text{derived} & \text{alternate} \\ \text{kg} \cdot \text{m} \cdot \text{A}^{-2} \cdot \text{s}^{-2} & \text{H/m} & \text{T} \cdot \text{m/A} \end{array}$ 

\neutronmass

\neutronmass

symbolapproximate precise

 $1.7\times10^{-27}$  $1.67492749804\times 10^{-27}$  $m_{\rm n}$ 

base derived alternatekg

kg kg

\oofpez

name

\oofpez

approximate precise  $_{
m symbol}$ 

 $\frac{1}{4\pi\varepsilon_o}$  $9\times10^{9}$  $8.9875517923\times 10^{9}$ 

base derived alternate  $\mathrm{kg}\cdot\mathrm{m}^{3}\cdot\mathrm{A}^{-2}\cdot\mathrm{s}^{-4}$ m/F $N \cdot m^2/C^2$ 

\oofpezcs

name

\oofpezcs

symbolapproximate precise  $\frac{1}{4\pi\varepsilon_{o}c^{2}}$  $10^{-7}$  $10^{-7}$ base derived alternate $\mathrm{kg}\cdot\mathrm{m}\cdot\mathrm{A}^{-2}\cdot\mathrm{s}^{-2}$  $T\cdot m^2$  $N \cdot s^2/C^2$ 

\planck (exact)

name

 $\planck$ 

symbolapproximate precise

 $6.6\times10^{-34}$  $6.62607015\times 10^{-34}$ h base derived alternate  $\mathrm{kg}\cdot\mathrm{m}^2\cdot\mathrm{s}^{-1}$  $J\cdot s$  $J\cdot \mathbf{s}$ 

\planckbar

name

\planckbar

approximate symbol precise

 $1.1\times10^{-34}$ ħ  $1.054571817\times 10^{-34}$ 

 $\mathbf{base}$ derived alternate $\mathrm{kg}\cdot\mathrm{m}^2\cdot\mathrm{s}^{-1}$  $J \cdot s$  $J \cdot s$ 

\planckc

\planckc

 ${\bf symbol} \hspace{1.5cm} {\bf approximate} \hspace{1.5cm} {\bf precise}$ 

hc  $2.0 \times 10^{-25}$   $1.98644586 \times 10^{-25}$ 

 $\begin{array}{lll} \text{base} & \text{derived} & \text{alternate} \\ \log \cdot m^3 \cdot s^{-2} & J \cdot m & J \cdot m \end{array}$ 

\protoncharge

name

\protoncharge

symbol approximate precise

 $q_p \\ +1.6 \times 10^{-19} \\ +1.602176634 \times 10^{-19}$ 

base derived alternate

 $A \cdot s$  C

\protonCharge

name

\protonCharge

symbol approximate precise

 $Q_p \\ +1.6 \times 10^{-19} \\ +1.602176634 \times 10^{-19}$ 

base derived alternate

 $A \cdot s$  C

\protonmass

name

\protonmass

symbol approximate precise

 $m_{\rm p}$  1.7 × 10<sup>-27</sup> 1.672621898 × 10<sup>-27</sup>

base derived alternate

kg kg

\rydberg

name

\rydberg

symbol approximate precise

 $R_{\infty} \hspace{1.5cm} 1.1 \times 10^{7} \hspace{1.5cm} 1.0973731568160 \times 10^{7}$ 

 $\begin{array}{ccc} \textbf{base} & & \textbf{derived} & & \textbf{alternate} \\ m^{-1} & & m^{-1} & & m^{-1} \end{array}$ 

\speedoflight (exact)

\speedoflight

 $\mathrm{m}\cdot\mathrm{s}^{-1}$   $\mathrm{m/s}$ 

\stefanboltzmann

name

\stefanboltzmann

 $\begin{array}{lllll} \text{symbol} & \text{approximate} & \text{precise} \\ \sigma & 5.7\times10^{-8} & 5.670374\times10^{-8} \\ \text{base} & \text{derived} & \text{alternate} \\ \text{kg}\cdot\text{s}^{-3}\cdot\text{K}^{-4} & \text{W/m}^2\cdot\text{K}^4 & \text{W/m}^2\cdot\text{K}^4 \end{array}$ 

\sunearthdistance

name

\sunearthdistance

 $\begin{array}{lll} \text{symbol} & \text{approximate} & \text{precise} \\ d_{SE} & 1.5 \times 10^{11} & 1.496 \times 10^{11} \\ \text{base} & \text{derived} & \text{alternate} \end{array}$ 

 $m \hspace{1.5cm} m \hspace{1.5cm} m$ 

\sunradius

name

\sunradius

 $m \hspace{1.5cm} m \hspace{1.5cm} m \hspace{1.5cm}$ 

\surfacegravfield

name

\surfacegravfield

\universalgrav

\universalgrav

#### \vacuumpermeability

name

\vacuumpermeability

 $\begin{array}{lll} \text{symbol} & \text{approximate} & \text{precise} \\ \mu_o & 4\pi\times 10^{-7} & 4\pi\times 10^{-7} \\ \text{base} & \text{derived} & \text{alternate} \\ kg\cdot m\cdot A^{-2}\cdot s^{-2} & H/m & T\cdot m/A \end{array}$ 

## \vacuumpermittivity

name

\vacuumpermittivity

symbol approximate precise

 $\epsilon_{\rm o}$  9 × 10  $^{-12}$  8.854187817 × 10  $^{-12}$ 

 $\begin{array}{ccc} \textbf{base} & \textbf{derived} & \textbf{alternate} \\ A^2 \cdot s^4 \cdot kg^{-1} \cdot m^{-3} & F/m & C^2/N \cdot m^2 \end{array}$ 

#### 3.4.4 Defining and Redefining Physical Constants

N 2021-02-16

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.

## 3.4.5 Changing Precision

Changing units<sup>-P. 24</sup> works for physical constants just as it does for physical quantities. A similar mechanism is provided for changing the precision of physical constants' numerical values.

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

Modal commands (switches) for setting the default precision for the entire document. The default when the package is loaded is set by the presence or absence of the preciseconstants P.8 key.

N 2021-02-16 N 2021-02-16 \hereuseapproximateconstants{ $\langle content \rangle$ } \hereusepreciseconstants{ $\langle content \rangle$ }

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

```
\( \hereuseapproximateconstants{\oofpez} \) \\ 9 \times 10^9 \, \mathrm{N} \cdot \mathrm{m}^2/\mathrm{C}^2 \( \hereusepreciseconstants{\oofpez} \) 8.9875517923 \times 10^9 \, \mathrm{N} \cdot \mathrm{m}^2/\mathrm{C}^2
```

N 2021-02-16

N 2021-02-16

N 2021-04-15

N 2021-04-15

N 2021-04-15

```
\begin{useapproximate constants} (use approximate constants)
\denvironment content\rangle
\end{useapproximateconstants}
\begin{usepreciseconstants} (use precise constants)
\denvironment content\rangle
\end{usepreciseconstants}
```

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

# 3.5 Predefined Units and Constructs

These commands should be used only in defining or redefining physical quantities or physical constants. One exception is **\emptyunit**, which may be used for explanatory purposes.

```
\per
\usk
\emptyunit
\ampere
\atomicmassunit
\candela
\coulomb
\degree
\electronvolt
                                                  (not SI but common in introductory physics)
                                                                                    (alias)
\ev
\farad
\henry
\hertz
\joule
\kelvin
                                                                                    (alias)
\kev
\kiloelectronvolt
                                                  (not SI but common in introductory physics)
\kilogram
\lightspeed
                                                              (not SI but common relativity)
```

\megaelectronvolt (not SI but common in introductory physics)
\meter

N 2021-04-15

\metre (alias) (alias) \mev \mole \newton \ohm \pascal \radian \second \siemens \steradian \tesla \volt \watt \weber (postfix) \tothetwo \tothethree (postfix) (postfix) \tothefour \inverse (postfix) (postfix) \totheinversetwo (postfix) \totheinversethree \totheinversefour (postfix)

```
3\,\mathrm{m/s}
                                                            П
\( \per \)
                                                            Α
\(\usk\)
                                                            u
\operatorname{cd}
\( \emptyunit \)
                                                            \mathbf{C}
\( \ampere \)
\( \atomicmassunit \)
\(\candela\)
                                                            eV
\( \coulomb \)
                                                            F
\( \degree \)
                                                            Η
\( \electronvolt \)
\( \farad \)
                                                            Hz
\( \henry \)
                                                            J
\( \hertz \)
                                                            Κ
\(\joule\)
\(\kelvin\)
                                                            keV
\( \kev \)
                                                            kg
\( \kilogram \)
                                                            \mathbf{c}
\( \lightspeed \)
                                                            \mathbf{m}
\( \meter \)
\( \metre \)
                                                            _{\mathrm{m}}
\( \mev \)
                                                            MeV
\( \mole \)
                                                            \operatorname{mol}
\( \newton \)
                                                            Ν
\( \ohm \)
\( \pascal \)
                                                            \Omega
\(\radian\)
                                                            Pa
rad
\mathbf{S}
\(\steradian\)
\( \tesla \)
                                                            S
\( \volt \)
                                                            \operatorname{sr}
\( \watt \)
                                                           \mathbf{T}
\( \weber \)
                                                            V
\( \emptyunit\tothetwo \)
\( \emptyunit\tothethree \)
                                                            W
\( \emptyunit\tothefour \)
                                       11
                                                            Wb
\( \emptyunit\inverse \)
                                                            \square^2
\( \emptyunit\totheinversetwo \)
                                                            \square^3
\(\emptyunit\totheinversethree\)\\
\( \emptyunit\totheinversefour \)
                                                            \Box^4
                                                            \square^{-1}
                                                           \Box^{-2}
                                                            \Box^{-3}
                                                            \Box^{-4}
```

```
\label{eq:local_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_continuous_cont
```

Commands for powers of ten and scientific notation.

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

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

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.

#### 3.6 mandi 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{3.0.0m}
2 \def\mandi@Date{2021-06-13}
3 \NeedsTeXFormat{LaTeX2e}[1999/12/01]
4 \providecommand\DeclareRelease[3]{}
5 \providecommand\DeclareCurrentRelease[2]{}
6 \DeclareRelease{v3.0.0m}{2021-06-13}{mandi.sty}
7 \DeclareCurrentRelease{v\mandi@Version}{\mandi@Date}
8 \ProvidesPackage{mandi}
    [\mandi@Date\space v\mandi@Version\space Macros for physical quantities]
   Define a convenient package version command.
10 \newcommand*{\mandiversion}{v\mandi@Version\space dated \mandi@Date}
   Load third party packages, documenting why each one is needed.
11 \RequirePackage{pgfopts}
                               % needed for key-value interface
12 \RequirePackage{array}
                               % needed for \checkquantity and \checkconstant
13 \RequirePackage{iftex}
                               % needed for requiring LuaLaTeX
14 \RequirePackage{unicode-math} % needed for Unicode support
15 \RequireLuaTeX
                               % require this engine
   The core unit engine has been completely rewritten in expl3 for both clarity and power.
   Generic internal selectors.
16 \newcommand*{\mandi@selectunits}{}
17 \newcommand*{\mandi@selectprecision}{}
   Specific internal selectors.
18 \newcommand*{\mandi@selectapproximate}[2]{#1}
                                                  % really \@firstoftwo
19 \newcommand*{\mandi@selectprecise}[2]{#2}
                                                  % really \@secondoftwo
20 \newcommand*{\mandi@selectbaseunits}[3]{#1}
                                                  % really \@firstofthree
21 \newcommand*{\mandi@selectderivedunits}[3]{#2}
                                                  % really \@secondofthree
22 \newcommand*{\mandi@selectalternateunits}[3]{#3} % really \@thirdofthree
   Document level global switches.
23 \NewDocumentCommand{\alwaysusebaseunits}{}
    {\renewcommand*{\mandi@selectunits}{\mandi@selectbaseunits}}%
25 \NewDocumentCommand{\alwaysusederivedunits}{}
    {\renewcommand*{\mandi@selectunits}{\mandi@selectderivedunits}}%
27 \NewDocumentCommand{\alwaysusealternateunits}{}
    {\renewcommand*{\mandi@selectunits}{\mandi@selectalternateunits}}%
29 \NewDocumentCommand{\alwaysuseapproximateconstants}{}
    {\renewcommand*{\mandi@selectprecision}{\mandi@selectapproximate}}%
31 \NewDocumentCommand{\alwaysusepreciseconstants}{}
    {\renewcommand*{\mandi@selectprecision}{\mandi@selectprecise}}%
   Document level localized variants.
33 \NewDocumentCommand{\hereusebaseunits}{ m }{\begingroup\alwaysusebaseunits#1\endgroup}%
34 \NewDocumentCommand{\hereusederivedunits}{ m }{\begingroup\alwaysusederivedunits#1\endgroup}%
35 \NewDocumentCommand{\hereusealternateunits}{ m }{\begingroup\alwaysusealternateunits#1\endgroup}%
37 \NewDocumentCommand{\hereusepreciseconstants}{ m }{\begingroup\alwaysusepreciseconstants#1\endgroup}%
   Document level environments.
```

```
40 \NewDocumentEnvironment{usealternateunits}{}{\alwaysusealternateunits}{}}
41 \NewDocumentEnvironment{useapproximateconstants}{}{\alwaysuseapproximateconstants}{}}
42 \NewDocumentEnvironment{usepreciseconstants}{}{\alwaysusepreciseconstants}{}}%
   mandi now has a key-value interface, implemented with pgfopts and pgfkeys. There are two options:
units P.8, with values base, derived, or alternate selects the default form of units
preciseconstants 7.8, 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.
43 \newif\ifusingpreciseconstants
44 \pgfkeys{%
    /mandi/options/.cd,
45
    initial@setup/.style={%
46
      /mandi/options/buffered@units/.initial=alternate,%
47
    },%
48
    initial@setup,%
49
    preciseconstants/.is if=usingpreciseconstants,%
    units/.is choice,%
    units/.default=derived,%
52
    units/alternate/.style={/mandi/options/buffered@units=alternate},%
53
    units/base/.style={/mandi/options/buffered@units=base},%
    units/derived/.style={/mandi/options/buffered@units=derived},%
55
56 }%
   Process the options.
57 \ProcessPgfPackageOptions{/mandi/options}
   Write a banner to the console showing the options in use.
58 \typeout{}%
59 \typeout{mandi: You are using mandi \mandiversion.}%
60 \typeout{mandi: This package requires LuaLaTeX.}%
61 \typeout{mandi: Loadtime options...}
   Complete the banner by showing currently selected options. The value of the units P.8 key is used in situ to set the
default units.
62 \newcommand*{\mandi@do@setup}{%
    \csname alwaysuse\pgfkeysvalueof{/mandi/options/buffered@units}units\endcsname%
63
    \typeout{mandi: You will get \pgfkeysvalueof{/mandi/options/buffered@units}\space units.}%
64
    \ifusingpreciseconstants
65
66
      \alwaysusepreciseconstants
67
      \typeout{mandi: You will get precise constants.}%
68
    \else
      \alwaysuseapproximateconstants
69
      \typeout{mandi: You will get approximate constants.}%
70
    \fi
71
    \typeout{}%
72
73 }%
74 \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.
75 \NewDocumentCommand{\mandisetup}{ m }{%
    \IfValueT{#1}{%
      \pgfqkeys{/mandi/options}{#1}
77
78
      \typeout{}%
      \typeout{mandi: mandisetup options...}
79
      \mandi@do@setup
80
   }%
81
```

82 }%

Define units and related constructs 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.

```
83 \NewDocumentCommand{\per}{}{/}
84 \NewDocumentCommand{\usk}{}{\cdot}
85 \NewDocumentCommand{\unit}{ m m }{{\pi\,\\#2}}
86 \NewDocumentCommand{\ampere}{}{\symup{A}}}
87 \NewDocumentCommand{\atomicmassunit}{}{\symup{u}}
88 \NewDocumentCommand{\candela}{}\symup{cd}}
89 \NewDocumentCommand{\coulomb}{}{\symup{C}}
90 \NewDocumentCommand{\degree}{}{^{\circ}}
91 \NewDocumentCommand{\electronvolt}{}{\symup{eV}}
92 \NewDocumentCommand{\ev}{}{\electronvolt}
93 \NewDocumentCommand{\farad}{}{\symup{F}}
94 \NewDocumentCommand{\henry}{}{\symup{H}}}
95 \verb|\NewDocumentCommand{\hertz}{}{\symup{Hz}}|
96 \NewDocumentCommand{\joule}{}{\symup{J}}}
97 \NewDocumentCommand{\kelvin}{}{\symup{K}}
98 \NewDocumentCommand{\kev}{}{\kiloelectronvolt}
99 \NewDocumentCommand{\kiloelectronvolt}{}{\symup{keV}}
100 \NewDocumentCommand{\kilogram}{}{\symup{kg}}
101 \NewDocumentCommand{\lightspeed}{}{\symup{c}}
102 \NewDocumentCommand{\megaelectronvolt}{}{\symup{MeV}}
103 \NewDocumentCommand{\meter}{}{\symup{m}}
104 \NewDocumentCommand{\metre}{}{\meter}
105 \NewDocumentCommand{\mev}{}{\megaelectronvolt}
106 \NewDocumentCommand{\mole}{}{\symup{mol}}
107 \NewDocumentCommand{\newton}{}{\symup{N}}
108 \NewDocumentCommand{\ohm}{}{\symup\Omega}
109 \NewDocumentCommand{\pascal}{}\symup{Pa}}
110 \NewDocumentCommand{\radian}{}{\symup{rad}}
111 \NewDocumentCommand{\second}{}{\symup{s}}
112 \NewDocumentCommand{\siemens}{}{\symup{S}}
113 \NewDocumentCommand{\steradian}{}{\symup{sr}}
114 \NewDocumentCommand{\tesla}{}\symup{T}}
115 \NewDocumentCommand{\volt}{}{\symup{V}}
116 \NewDocumentCommand{\watt}{}{\symup{W}}
117 \NewDocumentCommand{\weber}{}{\symup{Wb}}
118 \NewDocumentCommand{\tothetwo}{}{^2}
                                                     % postfix 2
119 \NewDocumentCommand{\tothethree}{}{^3}
                                                     % postfix
120 \NewDocumentCommand{\tothefour}{}{^4}
                                                     % postfix 4
121 \NewDocumentCommand{\inverse}{}{^{-1}}
                                                     % postfix -1
122 \NewDocumentCommand{\totheinversetwo}{}{^{-2}}
                                                     % postfix -2
123 \NewDocumentCommand{\totheinversethree}{}{^{-3}} % postfix -3
124 \NewDocumentCommand{\totheinversefour}{}{^{-4}} % postfix -4
125 \NewDocumentCommand{\emptyunit}{}{\mdlgwhtsquare}
126 \NewDocumentCommand{\tento}{ m }{10^{#1}}
127 \NewDocumentCommand{\timestento}{ m }{\times\tento{#1}}
128 \NewDocumentCommand{\xtento}{ m }{\times\tento{#1}}
```

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.

```
129 \ExplSyntaxOn
130 \cs_new:Npn \mandi_newscalarquantity #1#2#3#4
131 {%
132 \cs_new:cpn {#1} ##1 {\unit{##1}{\mandi@selectunits{#2}{#3}{#4}}}%
133 \cs_new:cpn {#1value} ##1 {##1}%
134 \cs_new:cpn {#1baseunits} ##1 {\unit{##1}{\mandi@selectbaseunits{#2}{#3}{#4}}}%
```

```
\cs new:cpn {#1derivedunits} ##1 {\unit{##1}{\mandi@selectderivedunits{#2}{#3}{#4}}}%
135
     \cs_new:cpn {#1alternateunits} ##1 {\unit{##1}{\mandi@selectalternateunits{#2}{#3}{#4}}}%
136
     \cs_new:cpn {#1onlybaseunits} {\mandi@selectbaseunits{#2}{#3}{#4}}%
137
     \cs new:cpn {#1onlyderivedunits} {\mandi@selectderivedunits{#2}{#3}{#4}}%
138
     \cs_new:cpn {#1onlyalternateunits} {\mandi@selectalternateunits{#2}{#3}{#4}}%
139
140 }%
141 \NewDocumentCommand{\newscalarquantity}{ m m O{#2} O{#2} }%
     \mandi_newscalarquantity { #1 }{ #2 }{ #3 }{ #4 }%
143
144 }%
145 \ExplSyntaxOff
    Redefining an existing scalar quantity.
146 \ExplSyntaxOn
147 \cs_new:Npn \mandi_renewscalarquantity #1#2#3#4
148 {%
149
     \cs_set:cpn {#1} ##1 {\unit{##1}{\mandi@selectunits{#2}{#3}{#4}}}%
     \cs_set:cpn {#1value} ##1 {##1}%
150
     \cs_{et:cpn $$\#1$ aseunits} $\#1 {\displaystyle \{\mandi@selectbaseunits\}$$\#2}$$
     \cs set:cpn {#1derivedunits} ##1 {\unit{##1}{\mandi@selectderivedunits{#2}{#3}{#4}}}%
    \cs_set:cpn {#1alternateunits} ##1 {\unit{##1}{\mandi@selectalternateunits{#2}{#3}{#4}}}%
153
    \cs_set:cpn {#1onlybaseunits} {\mandi@selectbaseunits{#2}{#3}{#4}}%
154
     \cs_set:cpn {#1onlyderivedunits} {\mandi@selectderivedunits{#2}{#3}{#4}}%
155
     \cs_set:cpn {#1onlyalternateunits} {\mandi@selectalternateunits{#2}{#3}{#4}}%
156
157 }%
158 \NewDocumentCommand{\renewscalarquantity}{ m m O{#2} O{#2} }%
159 {%
     \mandi_renewscalarquantity { #1 }{ #2 }{ #3 }{ #4 }%
160
161 }%
162 \ExplSyntaxOff
    Defining a new vector quantity. Note that a corresponding scalar is also defined.
163 \ExplSyntaxOn
164 \cs_new:Npn \mandi_newvectorquantity #1#2#3#4
165 {%
166
     \mandi_newscalarquantity { #1 }{ #2 }{ #3 }{ #4 }%
     \cs_new:cpn {vector#1} ##1 {\unit{\mivector{##1}}{\mivector{##1}}{\mivector{##2}{#3}{#4}}}%
167
     \cs_new:cpn $$\#1 {\operatorname{\mivector}} $$\#1 {\operatorname{\mivector}} $$\#1}}{\operatorname{\mivecton}} $$
168
     \cs_new:cpn {vector#1value} ##1 {\mivector{##1}}%
169
     \cs_new:cpn {#1vectorvalue} ##1 {\mivector{##1}}%
170
     \cs_new:cpn {vector#1baseunits} ##1 {\unit{\mivector{##1}}}{\mandi@selectbaseunits{#2}{#3}{#4}}}%
171
172
     \cs_new:cpn {#1vectorbaseunits} ##1 {\unit{\mivector{##1}}}{\mandi@selectbaseunits{#2}{#3}{#4}}}%
     \cs_new:cpn {vector#1derivedunits} ##1 {\unit{\mivector{##1}}{\mandi@selectderivedunits{#2}{#3}{#4}}}%
173
     \cs_new:cpn $$\#1vectorderivedunits$ $\#1 {\displaystyle \#1}}{\mivector}$$\#1}$% $$\cs_new:cpn $$\#1vectorderivedunits$$$\#1}$$
174
     \cs_new:cpn {vector#1alternateunits} ##1 {\unit{\mivector{##1}}{\mandi@selectalternateunits{#2}{#3}{#4}}}%
175
     \cs_new:cpn {#1vectoralternateunits} ##1 {\unit{\mivector{##1}}{\mandi@selectalternateunits{#2}{#3}{#4}}}%
     \cs_new:cpn {vector#1onlybaseunits} {\mandi@selectbaseunits{#2}{#3}{#4}}%
177
     \cs new:cpn {#1vectoronlybaseunits} {\mandi@selectbaseunits{#2}{#3}{#4}}%
178
     \cs_new:cpn {vector#1onlyderivedunits} {\mandi@selectderivedunits{#2}{#3}{#4}}%
179
     \cs_new:cpn {#1vectoronlyderivedunits} {\mandi@selectderivedunits{#2}{#3}{#4}}%
180
     \cs_new:cpn {vector#1onlyalternateunits} {\mandi@selectalternateunits{#2}{#3}{#4}}%
181
     \cs_new:cpn {#1vectoronlyalternateunits} {\mandi@selectalternateunits{#2}{#3}{#4}}%
182
183 }%
184 \NewDocumentCommand{\newvectorquantity}{ m m O{#2} O{#2} }%
185 {%
186
     \mandi_newvectorquantity { #1 }{ #2 }{ #3 }{ #4 }%
187 }%
188 \ExplSyntaxOff
```

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

```
189 \ExplSyntaxOn
 190 \cs_new:Npn \mandi_renewvectorquantity #1#2#3#4
 191 {%
 192
                   \mandi_renewscalarquantity { #1 }{ #2 }{ #3 }{ #4 }%
                   \cs_{\text{princh}} $$ \cs_{\text{princh}} $$ \operatorname{cs_{\text{princh}}}_{\text{princh}} $$ \cs_{\text{princh}} 
 193
                   \cs_{et:cpn $\#1 \leq mind(eselectunits(\#2){\#3}{\#4})},
 194
                   \cs_set:cpn {vector#1value} ##1 {\mivector{##1}}%
                   \cs_set:cpn {#1vectorvalue} ##1 {\mivector{##1}}%
                   \cs_set:cpn {vector#1baseunits} ##1 {\unit{\mivector{##1}}{\mandi@selectbaseunits{#2}{#3}{#4}}}%
 197
                   \cs_set:cpn {#1vectorbaseunits} ##1 {\unit{\mivector{##1}}}{\mandi@selectbaseunits{#2}{#3}{#4}}}%
 198
                   \cs_set:cpn {vector#1derivedunits} ##1 {\unit{\mivector{##1}}{\mandi@selectderivedunits{#2}{#3}{#4}}}%
199
                   \cs_{\#1}{\mathbf{\#1}}{\mathbf{\#2}}{\#3}{\#4}}%
200
                   \cs_set:cpn {vector#1alternateunits} ##1 {\unit{\mivector{##1}}{\mandi@selectalternateunits{#2}{#3}{#4}}}%
201
                   \cs_set:cpn {#1vectoralternateunits} ##1 {\unit{\mivector{##1}}{\mandi@selectalternateunits{#2}{#3}{#4}}}%
202
                   \cs_set:cpn {vector #1 only base units} {\mandi@select base units { #2 } { #3 } { #4 } } % { \mandi@select base units { #2 } { #3 } { #4 } } % { \mandi@select base units { #2 } { #3 } { #4 } } % { \mandi@select base units { #2 } { #3 } { #4 } } % { \mandi@select base units { #2 } { #3 } { #4 } } % { \mandi@select base units { #2 } { #3 } { #4 } } % { \mandi@select base units { $100 $ } } % { \mandi@select base units { $100 $ } } % { \mandi@select base units { $100 $ } } % { \mandi@select base units { $100 $ } } % { \mandi@select base units { $100 $ } } % { \mandi@select base units { $100 $ } } % { \mandi@select base units { $100 $ } } % { \mandi@select base units { $100 $ } } % { \mandi@select base units { $100 $ } } % { \mandi@select base units { $100 $ } } % { \mandi@select base units { $100 $ } } % { \mandi@select base units { $100 $ } } % { \mandi@select base units { $100 $ } } % { \mandi@select base units { $100 $ } } % { \mandi@select base units { $100 $ } } % { \mandi@select base units { $100 $ } } % { \mandi@select base units { $100 $ } } % { \mandi@select base units { $100 $ } } % { \mandi@select base units { $100 $ } } % { \mandi@select base units { $100 $ } } % { \mandi@select base units { $100 $ } } % { \mandi@select base units { $100 $ } } % { \mandi@select base units { $100 $ } } % { \mandi@select base units { $100 $ } } % { \mandi@select base units { $100 $ } } % { \mandi@select base units { $100 $ } } % { \mandi@select base units { $100 $ } } % { \mandi@select base units { $100 $ } } % { \mandi@select base units { $100 $ } } % { \mandi@select base units { $100 $ } } % { \mandi@select base units { $100 $ } } % { \mandi@select base units { $100 $ } } % { \mandi@select base units { $100 $ } } % { \mandi@select base units { $100 $ } } % { \mandi@select base units { $100 $ } } % { \mandi@select base units { $100 $ } } % { \mandi@select base units { $100 $ } } % { \mandi@select base units { $100 $ } } % { \mandi@select base units { $100 $ } } % { \mandi@select base units { $100 $ } } % { \mandi@sele
 203
                   \cs_set:cpn $${$\cs_set:cpn $$ {\bf {\cs_set:cpn {\tt {\#1}}{\tt {\#3}}{\tt {\#4}}}}},
204
                   \cs_set:cpn {vector#1onlyderivedunits} {\mandi@selectderivedunits{#2}{#3}{#4}}%
205
                   \cs_{et:cpn {\#1}vectoronlyderivedunits} {\mandi@selectderivedunits{\#2}{\#3}{\#4}} \% 
206
                   \cs_set:cpn {vector#1onlyalternateunits} {\mandi@selectalternateunits{#2}{#3}{#4}}%
207
 208
                   \cs_set:cpn {#1vectoronlyalternateunits} {\mandi@selectalternateunits{#2}{#3}{#4}}%
209 }%
210 \NewDocumentCommand{\renewvectorquantity}{ m m O{#2} O{#2} }%
211 {%
                   \mandi_renewvectorquantity { #1 }{ #2 }{ #3 }{ #4 }%
212
213 }%
214 \ExplSyntaxOff
                Defining a new physical constant.
215 \ExplSyntaxOn
216 \cs_new:Npn \mandi_newphysicalconstant #1#2#3#4#5#6#7
217 {%
218
                  \cs_new:cpn {#1} {\unit{\mandi@selectprecision{#3}{#4}}{\mandi@selectunits{#5}{#6}{#7}}}%
                   \cs_new:cpn {#1mathsymbol} {#2}%
219
                   \cs_new:cpn {#1approximatevalue} {#3}%
220
                   \cs_new:cpn {#1precisevalue} {#4}%
221
                   \cs_new:cpn {#1baseunits}
222
                          {\model @selectprecision $\{43\}{\model @select baseunits $\{5\}{\model @select baseunits $\{45\}{\model @select baseunits $\{45\}
223
                   \cs_new:cpn {#1derivedunits}
225
                           {\unit{\mandi@selectprecision{#3}{#4}}}{\mandi@selectderivedunits{#5}{#6}{#7}}}%
                   \cs new:cpn {#1alternateunits}
226
                        {\unit{\mandi@selectprecision{#3}{#4}}{\mandi@selectalternateunits{#5}{#6}{#7}}}%
227
228
                   \cs_new:cpn {#1onlybaseunits} {\mandi@selectbaseunits{#5}{#6}{#7}}%
229
                   \cs_new:cpn {#1onlyderivedunits} {\mandi@selectderivedunits{#5}{#6}{#7}}%
230
                   \cs new:cpn {#1onlyalternateunits} {\mandi@selectalternateunits{#5}{#6}{#7}}%
231 }%
232 \NewDocumentCommand{\newphysicalconstant}{ m m m m 0{#5} 0{#5} }%
233 {%
                  \mandi_newphysicalconstant { #1 }{ #2 }{ #3 }{ #4 }{ #5 }{ #6 }{ #7 }%
234
235 }%
236 \ExplSyntaxOff
                Redefining an existing physical constant.
237 \ExplSyntaxOn
238 \cs_new:Npn \mandi_renewphysicalconstant #1#2#3#4#5#6#7
239 {%
                \cs_{#1} {\unit{\mathcal{E}}{#5}{#6}{#7}}% $$ \cs_{#1} {\unit{\mathcal{E}}{#6}{#7}}% $$ \cs_{#1} {\unit{\mathbb{E}}{#6}{#7}}% $$ \cs_{#1} {\unit{\mathbb{E}}{#6}{$1$}}% $$ \cs_{#1} {\unit{\mathbb{E}}{*4}{$1$}}% $$ \cs_{\#} {\unit{\mathbb{E}}{*4}{$1$}}% $$ \cs_{\#} {\unit{\mathbb{E}}{*4}{$1$}}% $$ 
240
                   \cs_set:cpn {#1mathsymbol} {#2}%
241
242 \cs_set:cpn {#1approximatevalue} {#3}%
```

```
\cs set:cpn {#1precisevalue} {#4}%
243
     \cs_set:cpn {#1baseunits}
244
       {\unit{\mandi@selectprecision{#3}{#4}}{\mandi@selectbaseunits{#5}{#6}{#7}}}%
245
     \cs_set:cpn {#1derivedunits}
246
       {\unit{\mandi@selectprecision{#3}{#4}}}{\mandi@selectderivedunits{#5}{#6}{#7}}}%
247
     \cs set:cpn {#1alternateunits}
248
249
       {\unit{\mandi@selectprecision{#3}{#4}}{\mandi@selectalternateunits{#5}{#6}{#7}}}%
     \cs set:cpn {#1onlybaseunits} {\mandi@selectbaseunits{#5}{#6}{#7}}%
250
     \cs set:cpn {#1onlyderivedunits} {\mandi@selectderivedunits{#5}{#6}{#7}}%
251
     \cs_set:cpn {#1onlyalternateunits} {\mandi@selectalternateunits{#5}{#6}{#7}}%
252
253 }%
254 \NewDocumentCommand{\renewphysicalconstant}{ m m m m 0{#5} 0{#5} }%
255 {%
     \mandi renewphysicalconstant { #1 }{ #2 }{ #3 }{ #4 }{ #5 }{ #6 }{ #7 }%
257 }%
258 \ExplSyntaxOff
```

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.

```
259 \newvectorquantity{acceleration}%
     {\meter\usk\second\totheinversetwo}%
     [\newton\per\kilogram]%
261
     [\meter\per\second\tothetwo]%
262
263 \newscalarquantity{amount}%
     {\mole}%
265 \newvectorquantity{angularacceleration}%
     {\radian\usk\second\totheinversetwo}%
     [\radian\per\second\tothetwo]%
267
     [\radian\per\second\tothetwo]%
269 \newscalarquantity{angularfrequency}%
    {\radian\usk\second\inverse}%
270
     [\radian\per\second]%
271
     [\radian\per\second]%
273 %\ifmandi@rotradians
274 % \newphysicalquantity{angularimpulse}%
275 %
        {\meter\tothetwo\usk\kilogram\usk\second\inverse\usk\radian\inverse}%
276 %
        [\joule\usk\second\per\radian]%
277 %
        [\newton\usk\meter\usk\second\per\radian]%
278 %
      \newphysicalquantity{angularmomentum}%
        {\meter\tothetwo\usk\kilogram\usk\second\inverse\usk\radian\inverse}%
279 %
        [\kilogram\usk\meter\tothetwo\per(\second\usk\radian)]%
280 %
        [\newton\usk\meter\usk\second\per\radian]%
281 %
282 %\else
     \newvectorquantity{angularimpulse}%
283
       {\kilogram\usk\meter\tothetwo\usk\second\inverse}%
284
       285
       [\kilogram\usk\meter\tothetwo\per\second]% % also \newton\usk\meter\usk\second
286
     \newvectorquantity{angularmomentum}%
287
       {\kilogram\usk\meter\tothetwo\usk\second\inverse}%
288
       [\kilogram\usk\meter\tothetwo\per\second]% % also \joule\usk\second
289
       [\kilogram\usk\meter\tothetwo\per\second]% % also \newton\usk\meter\usk\second
290
292 \newvectorquantity{angularvelocity}%
     {\radian\usk\second\inverse}%
     [\radian\per\second]%
     [\radian\per\second]%
296 \newscalarquantity{area}%
    {\meter\tothetwo}%
```

```
298 \newscalarquantity{areachargedensity}%
299
     {\ampere\usk\second\usk\meter\totheinversetwo}%
     [\coulomb\per\meter\tothetwo]%
300
     [\coulomb\per\meter\tothetwo]%
301
302 \newscalarquantity{areamassdensity}%
     {\kilogram\usk\meter\totheinversetwo}%
     [\kilogram\per\meter\tothetwo]%
     [\kilogram\per\meter\tothetwo]%
305
306 \newscalarquantity{capacitance}%
     {\ampere\tothetwo\usk\second\tothefour\usk\kilogram\inverse\usk\meter\totheinversetwo}%
     [\farad]%
308
     [\coulomb\per\volt]% % also \coulomb\tothetwo\per\newton\usk\meter, \second\per\ohm
309
310 \newscalarquantity{charge}%
     {\ampere\usk\second}%
     [\coulomb]%
312
     [\coulomb]% % also \farad\usk\volt
313
314 \newvectorquantity{cmagneticfield}%
     {\kilogram\usk\meter\usk\ampere\inverse\usk\second\totheinversethree}%
     [\newton\per\coulomb]% % also \volt\per\meter
316
     [\newton\per\coulomb]%
318 \newscalarquantity{conductance}%
     {\tt \{\ampere\tothetwo\usk\second\tothethree\usk\kilogram\inverse\usk\meter\totheinversetwo\}\%}
319
     [\siemens]%
320
     [\ampere\per\volt]%
321
322 \newscalarquantity{conductivity}%
     {\ampere\tothetwo\usk\second\tothethree\usk\kilogram\inverse\usk\meter\totheinversethree}%
323
     [\siemens\per\meter]%
324
     [\ampere\per\volt\usk\meter]%
325
326 \newscalarquantity{conventionalcurrent}%
     {\ampere}%
327
     [\coulomb\per\second]%
328
     [\ampere]%
329
330 \newscalarquantity{current}%
     {\ampere}%
332 \newscalarquantity{currentdensity}%
     {\ampere\usk\meter\totheinversetwo}%
333
     [\coulomb\per\second\usk\meter\tothetwo]%
334
     [\ampere\per\meter\tothetwo]%
335
336 \newscalarquantity{dielectricconstant}%
337
338 \newvectorquantity{displacement}%
     {\meter}
339
340 \newscalarquantity{duration}%
     {\second}%
342 \newvectorquantity{electricdipolemoment}%
     {\ampere\usk\second\usk\meter}%
     [\coulomb\usk\meter]%
344
     [\coulomb\usk\meter]%
345
346 \newvectorquantity{electricfield}%
     {\kilogram\usk\meter\usk\ampere\inverse\usk\second\totheinversethree}%
347
     [\volt\per\meter]%
348
     [\newton\per\coulomb]%
349
350 \newscalarquantity{electricflux}%
     {\kilogram\usk\meter\tothethree\usk\ampere\inverse\usk\second\totheinversethree}}
351
     [\volt\usk\meter]%
352
     [\newton\usk\meter\tothetwo\per\coulomb]%
353
354 \newscalarquantity{electricpotential}%
     {\kilogram\usk\meter\tothetwo\usk\ampere\inverse\usk\second\totheinversethree}}
     [\volt]% % also \joule\per\coulomb
```

```
[\volt]%
357
358 \newscalarquantity{electricpotentialdifference}%
     {\kilogram\usk\meter\tothetwo\usk\ampere\inverse\usk\second\totheinversethree}}
359
     [\volt]% % also \joule\per\coulomb
360
     [\volt]%
361
362 \newscalarquantity{electroncurrent}%
     {\second\inverse}%
     [\ensuremath{\symup{e}}\per\second]%
364
     [\ensuremath{\symup{e}}\per\second]%
365
366 \newscalarquantity{emf}%
     {\kilogram\usk\meter\tothetwo\usk\ampere\inverse\usk\second\totheinversethree}}
367
     [\volt]% % also \joule\per\coulomb
368
     [\volt]%
370 \newscalarquantity{energy}%
     {\kilogram\usk\meter\tothetwo\usk\second\totheinversetwo}%
371
     [\joule]% % also \newton\usk\meter
372
     [\joule]%
373
374 \newscalarquantity{energyinev}%
     {\electronvolt}%
376 \newscalarquantity{energyinkev}%
     {\kiloelectronvolt}%
378 \newscalarquantity{energyinmev}%
     {\megaelectronvolt}%
380 \newscalarquantity{energydensity}%
     {\kilogram\usk\meter\inverse\usk\second\totheinversetwo}%
381
382
     [\joule\per\meter\tothethree]%
     [\joule\per\meter\tothethree]%
384 \newscalarquantity{energyflux}%
     {\kilogram\usk\second\totheinversethree}%
385
     [\watt\per\meter\tothetwo]%
386
     [\watt\per\meter\tothetwo]%
387
388 \newscalarquantity{entropy}%
     {\kilogram\usk\meter\tothetwo\usk\second\totheinversetwo\usk\kelvin\inverse}%
     [\joule\per\kelvin]%
390
     [\joule\per\kelvin]%
391
392 \newvectorquantity{force}%
     {\kilogram\usk\meter\usk\second\totheinversetwo}%
     [\newton]%
394
     [\newton]% % also \kilogram\usk\meter\per\second\tothetwo
395
396 \newscalarquantity{frequency}%
     {\second\inverse}%
397
     [\hertz]%
398
     [\hertz]%
399
400 \newvectorquantity{gravitationalfield}%
     {\meter\usk\second\totheinversetwo}%
402
     [\newton\per\kilogram]%
     [\newton\per\kilogram]%
404 \newscalarquantity{gravitationalpotential}%
     {\meter\tothetwo\usk\second\totheinversetwo}%
405
     [\joule\per\kilogram]%
406
     [\joule\per\kilogram]%
407
408 \newscalarquantity{gravitationalpotentialdifference}%
     {\meter\tothetwo\usk\second\totheinversetwo}%
     [\joule\per\kilogram]%
410
     [\joule\per\kilogram]%
411
412 \newvectorquantity{impulse}%
     {\bf \{\c kilogram\c k\c k\c cond\inverse\}\%}
413
414
     [\newton\usk\second]%
```

415

[\newton\usk\second]%

```
416 \newscalarquantity{indexofrefraction}%
     {}%
417
418 \newscalarquantity{inductance}%
     {\kilogram\usk\meter\tothetwo\usk\ampere\totheinversetwo\usk\second\totheinversetwo}%
419
     [\henry]%
420
     [\volt\usk\second\per\ampere]% % also \square\meter\usk\kilogram\per\coulomb\tothetwo, \Wb\per\ampere
421
422 \newscalarquantity{linearchargedensity}%
     {\ampere\usk\second\usk\meter\inverse}%
423
     [\coulomb\per\meter]%
424
     [\coulomb\per\meter]%
425
426 \newscalarquantity{linearmassdensity}%
     {\kilogram\usk\meter\inverse}%
     [\kilogram\per\meter]%
428
     [\kilogram\per\meter]%
429
430 \newscalarquantity{luminousintensity}%
     {\candela}%
431
432 \newscalarquantity{magneticcharge}%
     {\ampere\usk\meter}% % There is another convention. Be careful!
434 \newvectorquantity{magneticdipolemoment}%
     {\ampere\usk\meter\tothetwo}%
     [\ampere\usk\meter\tothetwo]%
436
     [\joule\per\tesla]%
437
438 \newvectorquantity{magneticfield}%
     {\kilogram\usk\ampere\inverse\usk\second\totheinversetwo}%
439
     [\newton\per\ampere\usk\meter]% % also \Wb\per\meter\tothetwo
440
     [\tesla]%
441
442 \newscalarquantity{magneticflux}%
     {\kilogram\usk\meter\tothetwo\usk\ampere\inverse\usk\second\totheinversetwo}%
443
     [\tesla\usk\meter\tothetwo]%
444
     [\volt\usk\second]% % also \Wb and \joule\per\ampere
445
446 \newscalarquantity{mass}%
     {\kilogram}%
448 \newscalarquantity{mobility}%
     {\kilogram\usk\meter\tothetwo\usk\ampere\inverse\usk\second\totheinversefour}%
449
     [\meter\tothetwo\per\volt\usk\second]%
450
     [\coulomb\usk\meter\per\newton\usk\second]%
452 \newscalarquantity{momentofinertia}%
     {\kilogram\usk\meter\tothetwo}%
453
     [\joule\usk\second\tothetwo]%
     [\kilogram\usk\meter\tothetwo]%
456 \newvectorquantity{momentum}%
     {\kilogram\usk\meter\usk\second\inverse}%
457
     [\kilogram\usk\meter\per\second]%
458
     [\kilogram\usk\meter\per\second]%
459
460 \newvectorquantity{momentumflux}%
461
     {\kilogram\usk\meter\inverse\usk\second\totheinversetwo}%
     [\newton\per\meter\tothetwo]%
462
     [\newton\per\meter\tothetwo]%
463
464 \newscalarquantity{numberdensity}%
     {\meter\totheinversethree}%
465
466
     [\per\meter\tothethree]%
     [\per\meter\tothethree]%
468 \newscalarquantity{permeability}%
     {\kilogram\usk\meter\usk\ampere\totheinversetwo\usk\second\totheinversetwo}}
469
     [\henry\per\meter]%
470
     [\tesla\usk\meter\per\ampere]%
471
472 \newscalarquantity{permittivity}%
473
     {\ampere\tothetwo\usk\second\tothefour\usk\kilogram\inverse\usk\meter\totheinversethree}%
```

[\farad\per\meter]%

```
[\coulomb\tothetwo\per\newton\usk\meter\tothetwo]%
475
476 \newscalarquantity{planeangle}%
     {\meter\usk\meter\inverse}%
477
     [\radian]%
478
     [\radian]%
479
480 \newscalarquantity{polarizability}%
     {\ampere\tothetwo\usk\second\tothefour\usk\kilogram\inverse}%
     [\coulomb\usk\meter\tothetwo\per\volt]%
482
     [\coulomb\tothetwo\usk\meter\per\newton]%
483
484 \newscalarquantity{power}%
     {\kilogram\usk\meter\tothetwo\usk\second\totheinversethree}%
485
     [\watt]%
486
     [\joule\per\second]%
488 \newvectorquantity{poynting}%
     {\kilogram\usk\second\totheinversethree}%
489
     [\watt\per\meter\tothetwo]%
490
     [\watt\per\meter\tothetwo]%
491
492 \newscalarquantity{pressure}%
     {\kilogram\usk\meter\inverse\usk\second\totheinversetwo}%
     [\pascal]%
     [\newton\per\meter\tothetwo]%
495
496 \newscalarquantity{relativepermeability}
497
498 \newscalarquantity{relativepermittivity}%
499
     {}%
500 \newscalarquantity{resistance}%
     {\kilogram\usk\meter\tothetwo\usk\ampere\totheinversetwo\usk\second\totheinversethree}}
     [\ohm]% % also \volt\per\ampere
502
     [\ohm]%
503
504 \newscalarquantity{resistivity}%
     {\kilogram\usk\meter\tothethree\usk\ampere\totheinversetwo\usk\second\totheinversethree}%
     [\ohm\usk\meter]%
506
     [\volt\usk\meter\per\ampere]%
508 \newscalarquantity{solidangle}%
     {\meter\tothetwo\usk\meter\totheinversetwo}%
     [\steradian]%
510
     [\steradian]%
511
512 \newscalarquantity{specificheatcapacity}%
     {\meter\tothetwo\usk\second\totheinversetwo\usk\kelvin\inverse}%
     [\joule\per\kelvin\usk\kilogram]%
514
     [\joule\per\kelvin\usk\kilogram]
515
516 \newscalarquantity{springstiffness}%
     {\kilogram\usk\second\totheinversetwo}%
517
     [\newton\per\meter]%
518
519
     [\newton\per\meter]%
520 \newscalarquantity{springstretch}% % This is really just a displacement.
522 \newscalarquantity{stress}%
     {\kilogram\usk\meter\inverse\usk\second\totheinversetwo}%
523
     [\pascal]%
524
     [\newton\per\meter\tothetwo]%
525
526 \newscalarquantity{strain}%
527
528 \newscalarquantity{temperature}%
    {\kelvin}%
530 %\ifmandi@rotradians
531 % \newphysicalquantity{torque}%
532 %
        {\kilogram\usk\meter\tothetwo\usk\second\totheinversetwo\usk\radian\inverse}%
533 %
        [\newton\usk\meter\per\radian]%
```

```
[\newton\usk\meter\per\radian]%
534 %
535 %\else
536 \newvectorquantity{torque}%
     {\kilogram\usk\meter\tothetwo\usk\second\totheinversetwo}%
537
     [\newton\usk\meter]%
538
     [\newton\usk\meter]%
539
540 %\fi
541 \newvectorquantity{velocity}%
     {\meter\usk\second\inverse}%
542
     [\meter\per\second]%
543
     [\meter\per\second]%
545 \newvectorquantity{velocityc}%
     {\lightspeed}%
546
     [\lightspeed]%
547
     [\lightspeed]%
548
549 \newscalarquantity{volume}%
     {\meter\tothethree}%
551 \newscalarquantity{volumechargedensity}%
     {\ampere\usk\second\per\meter\totheinversethree}%
553
     [\coulomb\per\meter\tothethree]%
     [\coulomb\per\meter\tothethree]%
554
555 \newscalarquantity{volumemassdensity}%
     {\kilogram\usk\meter\totheinversethree}%
556
     [\kilogram\per\meter\tothethree]%
557
     [\kilogram\per\meter\tothethree]%
558
559 \newscalarquantity{wavelength}% % This is really just a displacement.
     {\meter}%
560
561 \newvectorquantity{wavenumber}%
     {\meter\inverse}%
562
     [\per\meter]%
563
     [\per\meter]%
564
565 \newscalarquantity{work}%
     {\kilogram\usk\meter\tothetwo\usk\second\totheinversetwo}%
     [\joule]% % also \newton\usk\meter but discouraged
567
     [\joule]%
568
569 \mbox{ hewscalarquantity{youngsmodulus}}\% % This is really just a stress.
     {\kilogram\usk\meter\inverse\usk\second\totheinversetwo}%
     [\pascal]%
571
     [\newton\per\meter\tothetwo]%
572
    Define physical constants for introductory physics, again alphabetically for convenience.
573 \newphysicalconstant{avogadro}%
     {\sup\{N_A\}}%
574
     {6\times 16.02214076\times 23}}% exact 2019 value
575
576
     {\mole\inverse}%
577
     [\per\mole]%
     [\per\mole]%
578
579 \newphysicalconstant{biotsavartconstant}% % alias for \mzofp
     {\sup{\frac{\mu_o}{4\pi^2}}}
580
     {\left(-7\right)}{\left(-7\right)}
581
     {\bf \{\kilogram\usk\meter\usk\ampere\to the inverse two\usk\second\to the inverse two\}\%}
582
583
     [\henry\per\meter]%
     [\tesla\usk\meter\per\ampere]%
585 \newphysicalconstant{bohrradius}%
     {\sup\{a_o\}}%
586
     \{5.3\timestento\{-11\}\}\{5.29177210903\timestento\{-11\}\}\%
587
     {\meter}%
588
589 \newphysicalconstant{boltzmann}%
     {\sup\{k_B}}%
```

```
{1.4\timestento{-23}}{1.380649\timestento{-23}}% % exact 2019 value
591
592
               {\kilogram\usk\meter\tothetwo\usk\second\totheinversetwo\usk\kelvin\inverse}%
               [\joule\per\kelvin]%
593
               [\joule\per\kelvin]%
594
595 \newphysicalconstant{coulombconstant}% % alias for \oofpez
               {\symup{\frac{1}{4\pi\epsilon_o}}}%
597
               {9\timestento{9}}{8.9875517923\timestento{9}}%
              {\kilogram\usk\meter\tothethree\usk\ampere\totheinversetwo\usk\second\totheinversefour}%
598
               [\meter\per\farad]%
599
               [\newton\usk\meter\tothetwo\per\coulomb\tothetwo]%
600
601 \newphysicalconstant{earthmass}%
             {\symup{M_{Earth}}}%
              \{6.0 \times \{24\}\} \{5.9722 \times \{24\}\} \%
              {\kilogram}%
605 \newphysicalconstant{earthmoondistance}%
              {\symup{d_{EM}}}%
              {3.8\times \{3.8\times \{3.81550\times \{8\}\}\}}
607
              {\meter}%
608
609 \newphysicalconstant{earthradius}%
              {\symup{R_{Earth}}}%
              \{6.4 \times \{6.4 \times \{6.3781 \times \{6.3781 \times \{6.4 \times \{6.4 \times \{6.4 \times \{6.3781 \times \{6.3781 \times \{6.4 \times \{6
611
            {\meter}%
612
613 \newphysicalconstant{earthsundistance}%
              {\sup\{d_{ES}\}}%
              \{1.5\timestento\{11\}\}\{1.496\timestento\{11\}\}\%
615
              {\meter}%
616
617 \newphysicalconstant{electroncharge}%
              {\sup\{q_e\}}%
618
              {-\elementarychargeapproximatevalue}{-\elementarychargeprecisevalue}%
619
              {\ampere\usk\second}%
620
               [\coulomb]%
621
               [\coulomb]%
622
623 \newphysicalconstant{electronCharge}%
624
              {\sup{Q_e}}%
              {-\elementarychargeapproximatevalue}{-\elementarychargeprecisevalue}%
625
              {\ampere\usk\second}%
626
               [\coulomb]%
627
               [\coulomb]%
628
629 \newphysicalconstant{electronmass}%
              {\sup\{m_e\}}%
              {9.1\times -31}
631
              {\kilogram}%
633 \newphysicalconstant{elementarycharge}%
            {\symup{e}}%
634
              {1.6\timestento{-19}}{1.602176634\timestento{-19}}\% % exact 2019 value
635
              {\ampere\usk\second}%
               [\coulomb]%
               [\coulomb]%
638
639 \newphysicalconstant{finestructure}%
              {\sup{\alpha}}
640
              {\frac{1}{137}}{7.2973525693\times{-3}}%
641
642
643 \newphysicalconstant{hydrogenmass}%
              {\sup_{m_H}}%
              {1.7}\times{-27}{1.6737236}\times{-27}}%
645
646
              {\kilogram}%
647 \newphysicalconstant{moonearthdistance}%
648
            {\symup{d_{ME}}}%
              {3.8\times \{3.8\times \{3.81550\times \{8\}\}\}}
```

```
{\meter}%
650
651 \newphysicalconstant{moonmass}%
     {\symup{M_{Moon}}}%
652
     {7.3\times \{22\}}{7.342\times \{22\}}%
653
     {\kilogram}%
654
655 \newphysicalconstant{moonradius}%
    {\symup{R_{Moon}}}%
     \{1.7\timestento\{6\}\}\{1.7371\timestento\{6\}\}\%
657
    {\meter}%
658
659 \newphysicalconstant{mzofp}%
    {\sup{\frac{\mu_0}{4\pi c}}}
660
661
     {\left(-7\right)}{\left(-7\right)}
     {\kilogram\usk\meter\usk\ampere\totheinversetwo\usk\second\totheinversetwo}}
662
     [\henry\per\meter]%
     [\tesla\usk\meter\per\ampere]%
664
665 \newphysicalconstant{neutronmass}%
     {\sup_{m_n}}
666
     {1.7}\times{-27}{1.67492749804}\times{-27}}%
667
     {\kilogram}%
669 \newphysicalconstant{oofpez}%
     {\symup{\frac{1}{4\pi\epsilon_o}}}%
     {9}\times{9}\times{9}
671
     {\kilogram\usk\meter\tothethree\usk\ampere\totheinversetwo\usk\second\totheinversefour}%
672
     [\meter\per\farad]%
673
     [\newton\usk\meter\tothetwo\per\coulomb\tothetwo]%
674
675 \newphysicalconstant{oofpezcs}%
     {\sum_{c^2}}%
     {\left(-7\right)}{\left(-7\right)}
677
     {\kilogram\usk\meter\usk\ampere\totheinversetwo\usk\second\totheinversetwo}%
678
679
     [\tesla\usk\meter\tothetwo]%
     [\newton\usk\second\tothetwo\per\coulomb\tothetwo]%
680
681 \newphysicalconstant{planck}%
     {\sup\{h}}%
     \{6.6\timestento\{-34\}\}\{6.62607015\timestento\{-34\}\}\% % exact 2019 value
683
     {\kilogram\usk\meter\tothetwo\usk\second\inverse}%
684
     [\joule\usk\second]%
685
     [\joule\usk\second]%
686
    See https://tex.stackexchange.com/a/448565/218142.
687 \newphysicalconstant{planckbar}%
     {\symup{\lower0.18ex\hbox{\mathchar"AF}\mkern-7mu h}}%
688
     {1.1\times -34}{1.054571817\times -34}%
689
     {\kilogram\usk\meter\tothetwo\usk\second\inverse}%
690
     [\joule\usk\second]%
691
692
     [\joule\usk\second]
693 \newphysicalconstant{planckc}%
     {\symup{hc}}%
     \{2.0 \times \{-25\}\} \{1.98644586 \times \{-25\}\} \%
695
     {\kilogram\usk\meter\tothethree\usk\second\totheinversetwo}%
696
     [\joule\usk\meter]%
697
     [\joule\usk\meter]%
698
699 \newphysicalconstant{protoncharge}%
     {\sup\{q_p\}}%
700
     {+\elementarychargeapproximatevalue}{+\elementarychargeprecisevalue}%
701
702
     {\ampere\usk\second}%
703
     [\coulomb]%
     [\coulomb]%
705 \newphysicalconstant{protonCharge}%
     {\sup{Q_p}}%
```

```
{+\elementarychargeapproximatevalue}{+\elementarychargeprecisevalue}}
707
     {\ampere\usk\second}%
708
     [\coulomb]%
709
     [\coulomb]%
710
711 \newphysicalconstant{protonmass}%
     {\sup\{m_p\}}%
     \{1.7\timestento\{-27\}\}\{1.672621898\timestento\{-27\}\}\%
    {\kilogram}%
714
715 \newphysicalconstant{rydberg}%
     {\sup{R_{\min{y}}}}
     {1.1\times 10973731568160\times 10973731568160}
717
     {\meter\inverse}%
718
719 \newphysicalconstant{speedoflight}%
     {\symup{c}}%
720
721
     {3\timestento{8}}{2.99792458\timestento{8}}% % exact value
     {\meter\usk\second\inverse}%
722
723
     [\meter\per\second]%
     [\meter\per\second]
724
725 \newphysicalconstant{stefanboltzmann}%
     {\symup{\sigma}}%
     \{5.7\timestento\{-8\}\}\{5.670374\timestento\{-8\}\}\%
727
     {\kilogram\usk\second\totheinversethree\usk\kelvin\totheinversefour}%
728
     [\watt\per\meter\tothetwo\usk\kelvin\tothefour]%
729
     [\watt\per\meter\tothetwo\usk\kelvin\tothefour]
730
731 \newphysicalconstant{sunearthdistance}%
     {\symup{d_{SE}}}%
732
     \{1.5\timestento\{11\}\}\{1.496\timestento\{11\}\}\%
733
     {\meter}%
734
735 \newphysicalconstant{sunmass}%
     {\symup{M_{Sun}}}%
736
     {2.0\times {30}}{1.98855\times {30}}%
737
     {\kilogram}%
739 \newphysicalconstant{sunradius}%
     {\symup{R_{Sun}}}%
     {7.0\times 8}}{6.957\times 6.957}
741
     {\meter}%
743 \newphysicalconstant{surfacegravfield}%
    {\symup{g}}%
744
745
     {9.8}{9.807}%
     {\meter\usk\second\totheinversetwo}%
747
     [\newton\per\kilogram]%
     [\newton\per\kilogram]%
748
749 \newphysicalconstant{universalgrav}%
     {\sup\{G}}%
750
751
     \{6.7\timestento\{-11\}\}\{6.67430\timestento\{-11\}\}\%
     {\meter\tothethree\usk\kilogram\inverse\usk\second\totheinversetwo}%
     [\newton\usk\meter\tothetwo\per\kilogram\tothetwo]% % also \joule\usk\meter\per\kilogram\tothetwo
753
     [\newton\usk\meter\tothetwo\per\kilogram\tothetwo]%
754
755 \newphysicalconstant{vacuumpermeability}%
     {\sup\{\sum_{o}\}}
756
     {4\pi^{-7}} % as of 2018 no longer {\pi^{-7}} 4\pi\timestento{-7}
757
     {\kilogram\usk\meter\usk\ampere\totheinversetwo\usk\second\totheinversetwo}%
758
     [\henry\per\meter]%
     [\tesla\usk\meter\per\ampere]%
760
761 \newphysicalconstant{vacuumpermittivity}%
     {\symup{\epsilon_o}}%
762
      \{9 \times \{-12\}\} \{8.854187817 \times \{-12\}\} \% 
763
     {\ampere\tothetwo\usk\second\tothefour\usk\kilogram\inverse\usk\meter\totheinversethree}%
764
```

765

[\farad\per\meter]%

#### 766 [\coulomb\tothetwo\per\newton\usk\meter\tothetwo]%

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

```
767 \ExplSyntaxOn
768 \NewDocumentCommand{\checkquantity}{ m }%
769 {%
     % Works for both scalar and vector quantities (without vector in the name!).
770
     \begin{center}
771
       \begin{tabular}{%
772
           >{\bfseries\small}
773
           p{0.5\linewidth}
774
           p{0.1\linewidth}
775
776
           p{0.1\linewidth}
           p{0.1\linewidth}
777
778
         name & & & \tabularnewline
779
         \ttfamily\footnotesize{\token_to_str:c {#1}} & & & \tabularnewline
780
       \end{tabular}~ % This nonbreaking space is important!
781
       \begin{tabular}{%
782
783
           >{\bfseries\small}p{0.25\linewidth}
           >{\bfseries\small}p{0.25\linewidth}
784
           >{\bfseries\small}p{0.25\linewidth}
785
         }%
786
         base & derived & alternate \tabularnewline
787
         \footnotesize{\(\use:c {#1onlybaseunits}}
                                                        \)} &
788
         \footnotesize{\(\use:c {#1onlyderivedunits}
                                                        \)} &
789
         \footnotesize{\(\use:c {#1onlyalternateunits} \)}
790
       \end{tabular}
791
     \end{center}
792
793 }%
794 \NewDocumentCommand{\checkconstant}{ m }%
795 {%
796
     \begin{center}
       \begin{tabular}{%
797
           >{\bfseries\small}
798
           p{0.5\linewidth}
799
           p{0.1\linewidth}
800
           p{0.1\linewidth}
801
           p{0.1\linewidth}
802
803
         name & & & \tabularnewline
804
         \ttfamily\footnotesize{\token_to_str:c {#1}} & & & \tabularnewline
805
       \end{tabular}~ % This nonbreaking space is important!
806
       \begin{tabular}{%
807
           >{\bfseries\small}p{0.25\linewidth}
808
809
           >{\bfseries\small}p{0.25\linewidth}
           >{\bfseries\small}p{0.25\linewidth}
810
811
         symbol & approximate & precise \tabularnewline
812
         \footnotesize{\(\use:c {\#1mathsymbol}\}
                                                      \)} &
813
         814
         \footnotesize{\(\use:c {#1precisevalue}
815
       \end{tabular}~ % This nonbreaking space is important!
816
       \begin{tabular}{%
817
           {\proof*} 0.25\
818
           >{\bfseries\small}p{0.25\linewidth}
819
           {\proof*} 0.25\
820
821
         }%
822
         base & derived & alternate \tabularnewline
```

```
\footnotesize{\(\use:c {#1onlybaseunits}}
823
                                                          \)} &
         \footnotesize{\(\use:c {#1onlyderivedunits}}
                                                          \)} &
824
         \footnotesize{\(\use:c {#1onlyalternateunits} \)}
825
       \end{tabular}
826
     \end{center}
827
828 }%
829 \ExplSyntaxOff
    \mivector \(^{P.37}\) is a workhorse command. Orginal code provided by Qegreg.
See https://tex.stackexchange.com/a/39054/218142.
830 \ExplSyntaxOn
831 \NewDocumentCommand{\mivector}{ O{,} m o }%
832 {%
      \mi_vector:nn { #1 } { #2 }%
833
      \IfValueT{#3}{\,{#3}}%
834
835 }%
836 \seq_new:N \l__mi_list_seq
837 \cs_new_protected:Npn \mi_vector:nn #1 #2
838 {%
839
     \ensuremath{%
       \seq_set_split:Nnn \l__mi_list_seq { , } { #2 }
840
       \int_compare:nF { \seq_count:N \l__mi_list_seq = 1 } { \left\langle }
841
       \seq_use: Nnnn \l__mi_list_seq { #1 } { #1 } { #1 }
842
       \int_compare:nF { \seq_count:N \l_mi_list_seq = 1 } { \right\rangle }
843
844
    }%
845 }%
846 \ExplSyntaxOff
```

# 4 The mandistudent Package

mandi comes with an accessory package mandistudent, which provides a collection of commands physics students can use for writing problem solutions. These are not part of mandi's core functionality, but are included as a convenience to the bundle's target audience (introductory physics students). This new version focuses on the most frequently needed tools. These commands should always be used in math mode.

### 4.1 Traditional Vector Notation

```
\begin{tabular}{ll} $\\end{tabular} \begin{tabular}{ll} $\end{tabular} \begin{tabular}{ll} $\end{
```

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 LATEX \vec command.

```
\begin{array}{c} p\\ \\ (\ \langle \ \rangle_{\{2\}} \ ) \\ (\ \langle \ \rangle_{\{2\}} \ ) \\ (\ \langle \ \rangle_{\{symup\{ball\}\}} \ ) \\ (\ \langle \ \rangle_{\{symup\{final\}\}} \ ) \\ (\ \langle \ \rangle_{\{symup\{ball\}\}_{\{symup\{ball\}\}} \ ) \\ (\ \langle \ \rangle_{\{symup\{final\}\}_{\{symup\{ball\}\}} \ ) \\ (\ \langle \ \rangle_{\{p\}} \ ) \\ (\ \langle \ \rangle_{\{p\}} \ ) \\ \end{array}
```

```
\label{lambda} $$ \dirvec{\langle symbol \rangle} [\langle labels \rangle] $$ (use this variant for boldface notation) $$ \dirvec*{\langle symbol \rangle} [\langle labels \rangle] $$ (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.

```
\begin{array}{c} \widehat{p} \\ & \langle (\text{dirvec}\{p\} \setminus) \\ & \langle (\text{dirvec}\{p\}_{2} \setminus) \\ & \langle (\text{dirvec}\{p\}_{symup}\{ball}\} \setminus) \\ & \langle (\text{dirvec}\{p\}_{symup}\{final}\} \setminus) \\ & \langle (\text{dirvec}\{p\}_{symup}\{ball}\}_{symup}\{final}\} \setminus) \\ & \langle (\text{dirvec}\{p\}_{symup}\{final}\}_{symup}\{ball}\} \setminus) \\ & \langle (\text{dirvec}\{p\}_{symup}\{final}\}_{symup}\{ball}\} \setminus) \\ & \langle (\text{dirvec}\{p\}_{symup}\{final}\}_{symup}\{ball}\} \setminus) \\ & \widehat{p}_{final} \\ & \widehat{p}_{ball} \\ & \widehat{p}_{
```

```
\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.

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

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

```
\label{eq:linear_constraints} $$ \operatorname{\colored}_{\langle delimiter \rangle} (c_1, \dots, c_n) $$ \operatorname{\colored}_{\langle delimiter \rangle} (c_1, \dots, c_n) $$
```

Semantic aliases for \mivector→P.37.

#### \changein

Semantic alias for \Delta.

```
\( \changein t \) \\ \( \changein \vec{p} \) \\ \Delta p
```

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

```
\dot{doublebars}[\langle size \rangle] \{\langle quantity \rangle\}
                                                                                                                                                (double bars)
\doublebars*[\langle size \rangle] \{\langle quantity \rangle\}
                                                                                                                            (double bars for fractions)
\singlebars[\langle size \rangle] \{\langle quantity \rangle\}
                                                                                                                                                  (single bars)
\singlebars*[\langle size \rangle] \{\langle quantity \rangle\}
                                                                                                                              (single bars for fractions)
\agglebrackets[\langle size \rangle] \{\langle quantity \rangle\}
                                                                                                                                            (angle brackets)
\aglebrackets*[\langle size \rangle] \{\langle quantity \rangle\}
                                                                                                                        (angle brackets for fractions)
\parentheses[\langle size 
angle] \{\langle quantity 
angle\}
                                                                                                                                                (parentheses)
\operatorname{\mathtt{\baseline}} \{\langle \mathit{size} \rangle\} \{\langle \mathit{quantity} \rangle\}
                                                                                                                            (parentheses for fractions)
\squarebrackets[\langle size \rangle] \{\langle quantity \rangle\}
                                                                                                                                          (square brackets)
\squarebrackets*[\langle size \rangle] \{\langle quantity \rangle\}
                                                                                                                      (square brackets for fractions)
\curlybraces [\langle size \rangle] {\langle quantity\rangle}
                                                                                                                                                (curly braces)
\colon curly braces * [\langle size \rangle] \{\langle quantity \rangle\}
                                                                                                                           (curly braces for fractions)
```

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

```
|\cdot|
                                                                                                               |x|
\[ \singlebars{} \]
\[\singlebars{x} \]
\[\singlebars*{\frac{x}{3}} \]
                                                                                                               \left|\frac{x}{3}\right|
\[ \]  \[ \singlebars[\Bigg]{\frac{x}{3}} \]
                                                                                                               \frac{x}{3}
                                                                                                              \langle \, \cdot \, \rangle
                                                                                                              \langle m{a} 
angle
\[ \anglebrackets{} \]
\[ \anglebrackets{\vec{a}} \]
\[ \anglebrackets*{\frac{\vec{a}}{3}} \]
\[ \anglebrackets[\Bigg]{\frac{\vec{a}}{3}} \]
                                                                                                              (\,\cdot\,)
                                                                                                               (x)
\[ \parentheses{} \]
\[ \parentheses{x} \]
\[\] \[ \parentheses[\Bigg]{\frac{x}{3}} \]
                                                                                                               [\cdot]
                                                                                                               [x]
\[ \squarebrackets{} \]
\[\squarebrackets{x} \]
\[\squarebrackets*{\frac{x}{3}} \]
\label{linear_square_brackets} $$ \[ \squarebrackets[\Bigg]_{\frac_{x}_{3}} \] $$
```

```
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.

```
\|p\| \\ \  \|
```

N 2021-04-06 N 2021-04-06

```
\parallelto \perpendicularto
```

Commands for geometric relationships, mainly intended for subscripts.

```
\( \vec{F}_{\parallelto} + \vec{F}_{\perpendicularto} \) m{F}_{\parallel} + m{F}_{\perp}
```

#### 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{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} (use this variant for numbered steps)
\solution steps\
\end{physicssolution\*}
\begin{physicssolution\*} (use this variant for unnumbered steps)
\solution steps\
\end{physicssolution\*}

U 2021-02-26

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

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

U 2012-02-26

#### $\rcsin {\langle reason \rangle}$

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

### \hilite[ $\langle color \rangle$ ] { $\langle target \rangle$ } [ $\langle shape \rangle$ ]

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.

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

$$\Delta p = F_{\text{net}} \Delta t$$

U 2021-02-26

#### $\label{limited} $$ \simeq [\langle options \rangle] {\langle caption \rangle} {\langle label \rangle} {\langle image \rangle} $$$

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

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

1×1

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 61.
```

```
\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 62.
```

#### 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.

```
\label{local_colvec} $$ \operatorname{\colvec}[\langle delimiter \rangle] \{\langle c_1, \dots, c_n \rangle \} $$ $$ \operatorname{\colvec}[\langle delimiter \rangle] \{\langle c_1, \dots, c_n \rangle \} $$
```

Typesets column vectors and row vectors as numeric or symbolic components. There can be more than three components. The delimiter used in the list of components can be specified; the default is a comma. Units are not supported, so these are mainly for symbolic work.

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

```
\begin{tabular}{ll} $\langle symbol \rangle$ & (use this variant for coordinate-free vector notation) \\ $\langle symbol \rangle$ & (use this variant for index vector notation) \\ $\langle symbol \rangle$ & (use this variant for coordinate-free tensor notation) \\ $\langle symbol \rangle$ & (use this variant for index tensor notation) \\ $\langle symbol \rangle$ & (use this variant for index tensor notation) \\ $\langle symbol \rangle$ & (use this variant for index tensor notation) \\ $\langle symbol \rangle$ & (use this variant for index tensor notation) \\ $\langle symbol \rangle$ & (use this variant for index tensor notation) \\ $\langle symbol \rangle$ & (use this variant for index tensor notation) \\ $\langle symbol \rangle$ & (use this variant for index tensor notation) \\ $\langle symbol \rangle$ & (use this variant for index tensor notation) \\ $\langle symbol \rangle$ & (use this variant for index tensor notation) \\ $\langle symbol \rangle$ & (use this variant for index tensor notation) \\ $\langle symbol \rangle$ & (use this variant for index tensor notation) \\ $\langle symbol \rangle$ & (use this variant for index tensor notation) \\ $\langle symbol \rangle$ & (use this variant for index tensor notation) \\ $\langle symbol \rangle$ & (use this variant for index tensor notation) \\ $\langle symbol \rangle$ & (use this variant for index tensor notation) \\ $\langle symbol \rangle$ & (use this variant for index tensor notation) \\ $\langle symbol \rangle$ & (use this variant for index tensor notation) \\ $\langle symbol \rangle$ & (use this variant for index tensor notation) \\ $\langle symbol \rangle$ & (use this variant for index tensor notation) \\ $\langle symbol \rangle$ & (use this variant for index tensor notation) \\ $\langle symbol \rangle$ & (use this variant for index tensor notation) \\ $\langle symbol \rangle$ & (use this variant for index tensor notation) \\ $\langle symbol \rangle$ & (use this variant for index tensor notation) \\ $\langle symbol \rangle$ & (use this variant for index tensor notation) \\ $\langle symbol \rangle$ & (use this variant for index tensor notation) \\ $\langle symbol \rangle$ & (use this variant for index tensor notation) \\ $\langle symbol \rangle$ & (use this variant for index tensor notation) \\ $\langle symbol \rangle$ & (use this variant for index tensor notation) \\ $\langle symbol \rangle$ & (use this variant for index tensor notation) \\ $\langle symbol \rangle$ & (use
```

Conforms to ISO 80000-2 notation.

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

```
\label{localization} $$\operatorname{\constant}(index) + (index) +
```

Typesets tensor valence. The starred variant typesets it horizontally.

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

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

A vector is a \( (1,0) \) 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}
```

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

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

N 2021-04-06

#### \diff

Intelligent differential (exterior derivative) operator.

```
 \begin{cases} & \text{ int } x \text{ dx} \\ & \text{ int } x \text{ dx} \end{cases}
```

## 4.4 GlowScript and VPython Program Listings

GlowScript<sup>3</sup> and VPython<sup>4</sup> 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.

#### 4.5 The glowscriptblock Environment

U 2021-02-26

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

<sup>&</sup>lt;sup>3</sup>https://glowscript.org

<sup>&</sup>lt;sup>4</sup>https://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 66.
```

# 4.6 The vpythonfile Command

U 2021-02-26

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

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 32 # calculation loop while t < 10: 33 34 rate(100) # we need the stretch 35 s = mag(ball.pos) - Lo36 # we need the spring force 37 Fspring = ks \* s \* -norm(spring.axis) 38 Fnet = Fgrav + 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 68.
```

# 4.7 The glowscriptinline and vpythoninline Commands

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

```
\begin{tabular}{ll} $$ \glowscriptinline{$\langle GlowScript\ code\rangle$} \\ \begin{tabular}{ll} $\vertext{Python}\ code\rangle$} \end{tabular}
```

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

 $\label{local-continuity} $$ \GlowScript\ programs begin with \glowscriptinline{GlowScript 3.0 VPython} and \VPython\ programs begin with \vpythoninline{from vpython import *}.$ 

#### 4.8 mandistudent Source Code

847 \def\mandistudent@Version{3.0.0m} 848 \def\mandistudent@Date{2021-06-13} 849 \NeedsTeXFormat{LaTeX2e}[1999/12/01] 850 \providecommand\DeclareRelease[3]{} 851 \providecommand\DeclareCurrentRelease[2]{}

872 \RequireLuaTeX

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.

```
852 \DeclareRelease{v3.0.0m}{2021-06-13}{mandistudent.sty}
853 \DeclareCurrentRelease{v\mandi@Version}{\mandi@Date}
854 \ProvidesPackage{mandistudent}
    [\mandistudent@Date\space v\mandistudent@Version\space Macros for introductory physics]
    Define a convenient package version command.
856 \newcommand*{\mandistudentversion}{v\mandistudent@Version\space dated \mandistudent@Date}
    Load third party packages, documenting why each one is needed.
857 \RequirePackage{amsmath}
                                         % AMS goodness (don't load amssymb or amsfonts)
858 \RequirePackage[inline] {enumitem}
                                         \% needed for physicsproblem environment
859 \RequirePackage{eso-pic}
                                         % needed for \hilite
860 \RequirePackage[g]{esvect}
                                         % needed for nice vector arrow, style g
861 \RequirePackage{pgfopts}
                                         % needed for key-value interface
862 \RequirePackage{iftex}
                                         % needed for requiring LuaLaTeX
863 \RequirePackage{makebox}
                                         % needed for consistent \dirvect; \makebox
864 \RequirePackage{mathtools}
                                         % needed for paired delimiters; extends amsmath
865 \RequirePackage{nicematrix}
                                         % needed for column and row vectors
866 \RequirePackage[most]{tcolorbox}
                                         % needed for program listings
867 \RequirePackage{tensor}
                                         % needed for index notation
868 \RequirePackage{tikz}
                                         % needed for \hilite
869 \usetikzlibrary{shapes,fit,tikzmark} % needed for \hilite
870 \RequirePackage{unicode-math}
                                         % needed for Unicode support
871 \RequirePackage{hyperref}
                                         % load last
```

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 LualATEX.

% require this engine

```
873 \unimathsetup{math-style=ISO}
874 \unimathsetup{warnings-off={mathtools-colon,mathtools-overbracket}}
875 %
876 % Use normal math letters from Latin Modern Math for familiarity with
877 % textbooks.
878 %
879 %
        \begin{macrocode}
880 \setmathfont[Scale=MatchLowercase]
    {Latin Modern Math}
                            % default math font; better J
    Borrow from GeX Gyre DejaVu Math for vectors and tensors to get single-storey g.
882 \setmathfont[Scale=MatchLowercase,range={sfit/{latin},bfsfit/{latin}}]
     {TeX Gyre DejaVu Math} % single-storey lowercase g
    Borrow from GeX Gyre DejaVu Math to get single-storey g.
884 \setmathfont[Scale=MatchLowercase, range={sfup/{latin}, bfsfup/{latin}}]
    {TeX Gyre DejaVu Math} % single-storey lowercase g
Borrow mathscr and mathbfscr from XITS Math.
See https://tex.stackexchange.com/a/120073/218142.
886 \setmathfont[Scale=MatchLowercase,range={\mathscr,\mathbfscr}]{XITS Math}
```

Get original and bold mathcal fonts.

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

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

Borrow Greek sfup and sfit letters from STIX Two Math. Since this isn't officially supported in unicode-math we have to manually set this up.

```
888 \setmathfont[Scale=MatchLowercase,range={"E17C-"E1F6}]{STIX Two Math}
889 \newfontfamily{\symsfgreek}{STIX Two Math}
890 % I don't understand why \text{...} is necessary.
                                    {\text{\symsfgreek{^^^^e196}}}
891 \newcommand{\symsfupalpha}
892 \newcommand{\symsfupbeta}
                                     {\text{\symsfgreek{^^^^e197}}}
893 \newcommand{\symsfupgamma}
                                     {\text{\symsfgreek{^^^^e198}}}
                                    {\text{\symsfgreek{^^^^e199}}}
894 \newcommand{\symsfupdelta}
                                     {\text{\symsfgreek{^^^^e1af}}}
895 \newcommand{\symsfupepsilon}
896 \newcommand{\symsfupvarepsilon} {\text{\colored}}
897 \newcommand{\symsfupzeta}
                                     {\text{\symsfgreek{^^^^e19b}}}
                                     {\text{\symsfgreek{^^^^e19c}}}
898 \newcommand{\symsfupeta}
                                    {\text{\symsfgreek{^^^^e19d}}}
899 \newcommand{\symsfuptheta}
                                    {\text{\symsfgreek{^^^^e1b0}}}
900 \newcommand{\symsfupvartheta}
                                    {\text{\symsfgreek{^^^^e19e}}}
901 \newcommand{\symsfupiota}
                                     {\text{\symsfgreek{^^^^e19f}}}
902 \newcommand{\symsfupkappa}
                                     {\text{\symsfgreek{^^^^e1a0}}}
903 \newcommand{\symsfuplambda}
                                     {\text{\symsfgreek{^^^^e1a1}}}
904 \newcommand{\symsfupmu}
905 \newcommand{\symsfupnu}
                                     {\text{\symsfgreek{^^^^e1a2}}}
906 \newcommand{\symsfupxi}
                                     {\text{\symsfgreek{^^^^e1a3}}}
                                    {\text{\symsfgreek{^^^^e1a4}}}
907 \newcommand{\symsfupomicron}
                                    {\text{\symsfgreek{^^^^e1a5}}}
908 \newcommand{\symsfuppi}
                                    {\text{\symsfgreek{^^^^e1b3}}}
909 \newcommand{\symsfupvarpi}
910 \newcommand{\symsfuprho}
                                    {\text{\symsfgreek{^^^^e1a6}}}
911 \newcommand{\symsfupvarrho}
                                     {\text{\symsfgreek{\capacitantal}}}
                                    {\text{\symsfgreek{^^^^e1a8}}}
912 \newcommand{\symsfupsigma}
                                    {\text{\symsfgreek{^^^^e1a7}}}
913 \newcommand{\symsfupvarsigma}
                                    {\text{\symsfgreek{^^^^e1a9}}}
914 \newcommand{\symsfuptau}
                                     {\text{\symsfgreek{^^^^e1aa}}}
915 \newcommand{\symsfupupsilon}
                                     {\text{\symsfgreek{^^^^e1b1}}}
916 \newcommand{\symsfupphi}
                                     {\text{\symsfgreek{^^^^e1ab}}}
917 \newcommand{\symsfupvarphi}
918 \newcommand{\symsfupchi}
                                     {\text{\symsfgreek{\capaca}}}
919 \newcommand{\symsfuppsi}
                                     {\text{\symsfgreek{^^^^e1ad}}}
920 \newcommand{\symsfupomega}
                                    {\text{\symsfgreek{^^^^e1ae}}}
                                     {\text{\symsfgreek{^^^^e180}}}
921 \newcommand{\symsfupDelta}
                                     {\text{\colored} } {\text{\colored} }
922 \mbox{newcommand{\symsfupGamma}}
                                     {\text{\symsfgreek{^^^^e18e}}}
923 \newcommand{\symsfupTheta}
924 \newcommand{\symsfupLambda}
                                     {\text{\symsfgreek{\capaning}}}
                                    {\text{\symsfgreek{^^^^e18a}}}
925 \newcommand{\symsfupXi}
                                    {\text{\symsfgreek{^^^^e18c}}}
926 \newcommand{\symsfupPi}
                                    {\text{\colored} } {\text{\colored} }
927 \newcommand{\symsfupSigma}
                                     {\text{\symsfgreek{^^^^e191}}}
928 \newcommand{\symsfupUpsilon}
                                     {\text{\symsfgreek{^^^^e192}}}
929 \newcommand{\symsfupPhi}
                                     {\text{\symsfgreek{^^^^e194}}}
930 \newcommand{\symsfupPsi}
                                     {\text{\symsfgreek{^^^^e195}}}
931 \newcommand{\symsfupOmega}
                                     {\text{\symsfgreek{^^^^e1d8}}}
932 \newcommand{\symsfitalpha}
933 \newcommand{\symsfitbeta}
                                    {\text{\symsfgreek{^^^^e1d9}}}
934 \newcommand{\symsfitgamma}
                                     {\text{\symsfgreek{^^^^e1da}}}
                                    {\text{\symsfgreek{^^^^e1db}}}
935 \newcommand{\symsfitdelta}
                                     {\text{\symsfgreek{^^^^e1f1}}}
936 \newcommand{\symsfitepsilon}
937 \newcommand{\symsfitvarepsilon} {\text{\symsfgreek{^^^eldc}}}
                                     {\text{\symsfgreek{^^^^e1dd}}}
938 \newcommand{\symsfitzeta}
                                     {\text{\symsfgreek{^^^^e1de}}}
939 \newcommand{\symsfiteta}
```

```
940 \mbox{ } \mbox{newcommand{\symsfittheta}}
                                     {\text{\symsfgreek{^^^e1df}}}
941 \newcommand{\symsfitvartheta}
                                     {\text{\symsfgreek{^^^e1f2}}}
942 \newcommand{\symsfitiota}
                                     {\text{\symsfgreek{^^^^e1e0}}}
943 \newcommand{\symsfitkappa}
                                     {\text{\symsfgreek{^^^^e1e1}}}
944 \newcommand{\symsfitlambda}
                                     {\text{\symsfgreek{^^^^e1e2}}}
945 \newcommand{\symsfitmu}
                                     {\text{\symsfgreek{^^^^e1e3}}}
946 \newcommand{\symsfitnu}
                                     {\text{\symsfgreek{^^^^e1e4}}}
                                     {\text{\symsfgreek{^^^^e1e5}}}
947 \newcommand{\symsfitxi}
                                     {\text{\symsfgreek{^^^^e1e6}}}
948 \newcommand{\symsfitomicron}
949 \mbox{ } \mbox{newcommand{\symsfitpi}}
                                     {\text{\symsfgreek{^^^^e1e7}}}
                                     {\text{\symsfgreek{^^^^e1f5}}}
950 \newcommand{\symsfitvarpi}
                                     {\text{\symsfgreek{^^^^e1e8}}}
951 \newcommand{\symsfitrho}
                                     {\text{\symsfgreek{^^^^e1f4}}}
952 \newcommand{\symsfitvarrho}
                                     {\text{\symsfgreek{^^^^e1ea}}}
953 \newcommand{\symsfitsigma}
                                     {\text{\symsfgreek{^^^^e1e9}}}
954 \newcommand{\symsfitvarsigma}
955 \newcommand{\symsfittau}
                                     {\text{\symsfgreek{^^^^e1eb}}}
956 \newcommand{\symsfitupsilon}
                                     {\text{\symsfgreek{^^^^e1ec}}}
                                     {\text{\symsfgreek{^^^^e1f3}}}
957 \newcommand{\symsfitphi}
                                     {\text{\symsfgreek{^^^^e1ed}}}
958 \newcommand{\symsfitvarphi}
                                     {\text{\symsfgreek{^^^^e1ee}}}
959 \newcommand{\symsfitchi}
960 \newcommand{\symsfitpsi}
                                     {\text{\symsfgreek{^^^^e1ef}}}
                                     {\text{\symsfgreek{^^^^e1f0}}}
961 \newcommand{\symsfitomega}
                                     {\text{\symsfgreek{^^^^e1c2}}}
962 \newcommand{\symsfitDelta}
                                     {\text{\symsfgreek{^^^^e1c1}}}
963 \newcommand{\symsfitGamma}
                                     {\text{\symsfgreek{^^^^e1d0}}}
964 \mbox{newcommand{\symsfitTheta}}
                                     {\text{\symsfgreek{^^^^e1c9}}}
965 \newcommand{\symsfitLambda}
                                     {\text{\symsfgreek{^^^^e1cc}}}
966 \newcommand{\symsfitXi}
967 \newcommand{\symsfitPi}
                                     {\text{\symsfgreek{^^^^e1ce}}}
968 \newcommand{\symsfitSigma}
                                     {\text{\symsfgreek{^^^^e1d1}}}
969 \newcommand{\symsfitUpsilon}
                                     {\text{\symsfgreek{^^^^e1d3}}}
970 \mbox{newcommand{\symsfitPhi}}
                                     {\text{\symsfgreek{^^^^e1d4}}}
971 \newcommand{\symsfitPsi}
                                     {\text{\symsfgreek{^^^^e1d6}}}
972 \newcommand{\symsfitOmega}
                                     {\text{\symsfgreek{^^^^e1d7}}}
```

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

```
973 \DeclareFontFamily{U}{esvect}{}
974 \DeclareFontShape{U}{esvect}{m}{n}{%
975 <-5.5> vect5
976 <5.5-6.5> vect6
977 <6.5-7.5> vect7
978 <7.5-8.5> vect8
979 <8.5-9.5> vect9
980 <9.5-> vect10
981 }{}%
```

Write a banner to the console showing the options in use.

```
982 \typeout{}%
983 \typeout{mandistudent: You are using mandistudent \mandistudentversion.}%
984 \typeout{mandistudent: This package requires LuaLaTeX.}%
985 \typeout{mandistudent: This package changes the default math font(s).}%
986 \typeout{mandistudent: This package redefines the \protect\vec\space command.}%
987 \typeout{}%
```

A better, intelligent coordinate-free \vec<sup>¬P.54</sup> command. Note the use of the e{\_^} type of optional argument. This accounts for much of the flexibility and power of this command. Also note the use of the T<sub>E</sub>X 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 also https://tex.stackexchange.com/a/531037/218142.
988 \RenewDocumentCommand{\vec}{ s m e{_^} }{%
        % Note the \, used to make superscript look better.
989
        \IfBooleanTF {#1}
990
          {\vv{#2}%
                          % * gives an arrow
991
             % Use \sp{} primitive for superscript.
992
             % Adjust superscript for the arrow.
993
             \sp{\IfValueT{#4}{\,#4}\vphantom{\smash[t]{\big|}}}
994
995
          {\symbfit{#2} % no * gives us bold
996
             % Use \sp{} primitive for superscript.
997
             % No superscript adjustment needed.
998
             \sp{\IfValueT{#4}{#4}\vphantom{\smash[t]{\big|}}}
999
          }%
1000
1001
        % Use \sb{} primitive for subscript.
1002
        \sh\{\If ValueT{#3}{#3}\vphantom{\smash[b]{|}}}
1003 }%
     A command for the direction of a vector. We use a slight tweak to get uniform hats that requires the makebox package.
 See https://tex.stackexchange.com/a/391204/218142.
1004 \NewDocumentCommand{\dirvec}{ s m e{_^} }{%
        \widetilde{\mbox{(w)}}{\mbox{makebox*{(w))}{\mbox{maxemath{%}}}}
1005
          \IfBooleanTF {#1}
1006
            {%
1007
              #2
1008
            }%
1009
1010
            {%
               \symbfit{#2}
1011
1012
            }%
1013
           }%
          }%
1014
         }%
1015
        \sh\{\IfValueT{#3}{#3}\vphantom{\smash[b]{|}}}
1016
1017
        \sp{\IfValueT{#4}{\,#4}\vphantom{\smash[t]{\big|}}}
1018 }%
     The zero vector.
1019 \NewDocumentCommand{\zerovec}{ s }{%
      \IfBooleanTF {#1}
1021
        {\vv{0}}%
1022
        {\symbfup{0}}%
1023 }%
     Notation for column and row vectors. Orginal code provided by @egreg.
 See https://tex.stackexchange.com/a/39054/218142.
1024 \ExplSyntaxOn
1025 \NewDocumentCommand{\colvec}{ O{,} m }{%
      \vector_main:nnnn { p } { \\ } { #1 } { #2 }
1026
1027 }%
1028 \NewDocumentCommand{\rowvec}{ O{,} m }{%
      \vector_main:nnnn { p } { & } { #1 } { #2 }
1029
1030 }%
1031 \seq_new: N \l__vector_arg_seq
1032 \cs_new_protected:Npn \vector_main:nnnn #1 #2 #3 #4 {%
      \seq_set_split:Nnn \l__vector_arg_seq { #3 } { #4 }
1033
      \begin{#1NiceMatrix}[r]
1034
        \seq_use:Nnnn \l__vector_arg_seq { #2 } { #2 } { #2 }
1035
```

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

```
\end{#1NiceMatrix}
1036
1037 }%
1038 \ExplSyntaxOff
                Semantic aliases for \mivector → P. 37.
1039 \NewDocumentCommand{\direction}{}{\mivector}
1040 \NewDocumentCommand{\unitvector}{}{\mivector}
                 Students always need this symbol.
1041 \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.
1042 \ensuremath{\lowert}{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}_{\lowert}
1043 \DeclarePairedDelimiterX{\singlebars}[1]{\lvert}{\rvert}{\ifblank{#1}{\:\cdot\:}{#1}}
1044 \end{thm} $$1044 \end{thm} $$1044
1045 \ensuremath{\lower.1} \{1] \{() \{\} \} \in \mathbb{R}^{1} \{ \cdot \in \mathbb{R}^{1} \} \}
1046 \end{This property of the property of t
1047 \DeclarePairedDelimiterX{\curlybraces}[1]{\lbrace}{\rbrace}{\ifblank{#1}{\:\cdot\:}{#1}}
                 Important semantic aliases.
                 Some semantic aliases. Because of the way \vec<sup>\rightarrow P.54</sup> and \dirvec<sup>\rightarrow P.54</sup> are defined, I reluctantly decided not to implement
     a \magvec command. It would require accounting for too mamy options. So \magnitude \to P.57 is the new solution.
1048 \NewDocumentCommand{\magnitude}{}{\doublebars}
1049 \NewDocumentCommand{\norm}{}{\doublebars}
1050 \NewDocumentCommand{\absolutevalue}{}{\singlebars}
                 Commands for two important geometric relationships. These are meant mainly to be subscripts.
1051 \NewDocumentCommand{\parallelto}{}
                    {\mkern3mu\vphantom{\perp}\vrule depth Opt\mkern2mu\vrule depth Opt\mkern3mu}
1053 \NewDocumentCommand{\perpendicularto}{}
1054
                    {\perp}
                 An environment for problem statements. The starred variant gives in-line lists.
1055 \NewDocumentEnvironment{physicsproblem}{ m }{%
                    \newpage%
1056
                    \section*{#1}%
1057
                    \newlist{parts}{enumerate}{2}%
1058
                    \setlist[parts]{label=\bfseries(\alph*)}}%
1059
1060
1061 \NewDocumentEnvironment{physicsproblem*}{ m }{%
1062
                    \newpage%
                    \section*{#1}%
1063
                    \newlist{parts}{enumerate*}{2}%
1064
                    \setlist[parts]{label=\bfseries(\alph*)}}%
1065
1066
                    {}%
1067 \NewDocumentCommand{\problempart}{}{\item}%
                 An environment for problem solutions.
1068 \NewDocumentEnvironment{physicssolution}{ +b }{%
1069
                    % Make equation numbering consecutive through the document.
                    \begin{align}
1070
                           #1
1071
                    \end{align}
1074 \NewDocumentEnvironment{physicssolution*}{ +b }{%
                    % Make equation numbering consecutive through the document.
1075
                    \begin{align*}
1076
```

#1

1077

```
\end{align*}
1078
1079 }{}%
     See https://tex.stackexchange.com/q/570223/218142.
1080 \NewDocumentCommand{\reason}{ O{4cm} m }
      {&&\begin{minipage}{#1}\raggedright\small #2\end{minipage}}
     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.
1082 \newcounter{tikzhighlightnode}
1083 \NewDocumentCommand{\hilite}{ O{magenta!60} m O{rectangle} }{%
      \stepcounter{tikzhighlightnode}%
1085
      \tikzmarknode{highlighted-node-\number\value{tikzhighlightnode}}{#2}%
1086
      \edef\temp{%
        \noexpand\AddToShipoutPictureBG{%
1087
          \noexpand\begin{tikzpicture}[overlay,remember picture]%
1088
          \noexpand\iftikzmarkoncurrentpage{highlighted-node-\number\value{tikzhighlightnode}}%
1089
           \noexpand\node[inner sep=1.0pt,fill=#1,#3,fit=(highlighted-node-\number\value{tikzhighlightnode})]{};%
1090
1091
          \noexpand\fi
1092
          \noexpand\end{tikzpicture}%
        }%
1093
1094
      }%
      \temp%
1095
1096 }%
     A simplified command for importing images.
1097 \NewDocumentCommand{\image}{ O{scale=1} m m m }{%
      \begin{figure}[ht!]
1098
        \begin{center}%
1099
          \includegraphics[#1]{#2}%
1100
        \end{center}%
1101
        \caption{#3}%
1102
        \label{#4}%
1103
      \end{figure}%
1104
1105 }%
     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.
1106 \NewDocumentCommand{\veccomp}{ s m }{%
      % Consider renaming this to \vectorsym.
1107
      \IfBooleanTF{#1}
1108
1109
      {%
1110
        \symnormal{#2}%
1111
      }%
1112
      {%
        \symbfit{#2}%
1113
```

1114

1115 }%

}%

1116 \NewDocumentCommand{\tencomp}{ s m }{%

\IfBooleanTF{#1}

% Consider renaming this to \tensororsym.

```
1119
      {%
        \svmsfit{#2}%
1120
      }%
1121
1122
      {%
        \symbfsfit{#2}
1123
1124
      }%
1125 }%
     Command to typeset tensor valence.
1126 \NewDocumentCommand{\valence}{ s m m }{%
      \IfBooleanTF{#1}
        {(#2,#3)}
1128
        {\binom{#2}{#3}}
1129
1130 }%
     Intelligent notation for contraction on pairs of slots.
1131 \NewDocumentCommand{\contraction}{ s m }{%
      \IfBooleanTF{#1}
1132
      {\mathbf C}}%
1133
      {\symbb{C}}%
1135
     _{#2}
1136 }%
     Intelligent slot command for coordinate-free tensor notation.
1137 \NewDocumentCommand{\slot}{ s d[] }{%
      \% d[] must be used because of the way consecutive optional
      \% arguments are handled. See xparse docs for details.
1139
1140
      \IfBooleanTF{#1}
1141
        \IfValueTF{#2}
1142
        {% Insert a vector, but don't show the slot.
1143
          \smash{\makebox[1.5em]{\ensuremath{#2}}}
1144
1145
        {% No vector, no slot.
1146
          \smash{\makebox[1.5em]{\ensuremath{}}}
1147
        }%
1148
      }%
1149
1150
        \IfValueTF{#2}
1151
        {% Insert a vector and show the slot.
1152
          \underline{\smash{\makebox[1.5em]{\ensuremath{#2}}}}
1153
1154
        {% No vector; just show the slot.
1155
          \underline{\smash{\makebox[1.5em]{\ensuremath{}}}}
1156
        }%
1157
    }%
1158
1159 }%
     Intelligent differential (exterior derivative) operator.
1160 \NewDocumentCommand{\diff}{ s }{%
      \mathop{}\!
1161
1162
      \IfBooleanTF{#1}
1163
      {\symbfsfup{d}}%
1164
      {\symsfup{d}}%
1165 }%
1166 \directlua{%
1167 luaotfload.add_colorscheme("colordigits",
       {["8000FF"] = {"one", "two", "three", "four", "five", "six", "seven", "eight", "nine", "zero"}})
1168
1169 }%
1170 \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.

```
1171 \newfontfamily{\gsfontfamily}{DejaVuSansMono}
                                                         % new font for listings
1172 \definecolor{gsbggray}
                                 {rgb}{0.90,0.90,0.90} % background gray
1173 \definecolor{gsgray}
                                 \{rgb\}\{0.30,0.30,0.30\} % gray
1174 \definecolor{gsgreen}
                                 {rgb}{0.00,0.60,0.00} % green
1175 \definecolor{gsorange}
                                 \{rgb\}\{0.80,0.45,0.12\} % orange
1176 \definecolor{gspeach}
                                 {rgb}{1.00,0.90,0.71} % peach
1177 \definecolor{gspearl}
                                 {rgb}{0.94,0.92,0.84} % pearl
                                 {rgb}{0.74,0.46,0.70} % plum
1178 \definecolor{gsplum}
                                                         % style for listings
1179 \lstdefinestyle{vpython}{%
      backgroundcolor=\color{gsbggray},%
                                                         % background color
1180
      basicstyle=\colordigits\footnotesize,%
1181
                                                         % default style
      breakatwhitespace=true%
                                                         % break at whitespace
1182
      breaklines=true,%
                                                         % break long lines
1183
1184
      captionpos=b,%
                                                         % position caption
                                                         % STILL DON'T UNDERSTAND THIS
1185
      classoffset=1.%
      commentstyle=\color{gsgray},%
                                                         % font for comments
1186
      deletekeywords={print},%
                                                         % delete keywords from the given language
1187
      emph={self,cls,@classmethod,@property},%
                                                         % words to emphasize
1188
      emphstyle=\color{gsorange}\itshape,%
                                                         % font for emphasis
1189
      escapeinside=\{(*0)\}\{(0*)\},\%
                                                         % add LaTeX within your code
1190
      frame=tb,%
                                                         % frame style
1191
      framerule=2.0pt,%
                                                         % frame thickness
1192
      framexleftmargin=5pt,%
                                                         % extra frame left margin
1193
      %identifierstyle=\sffamily,%
                                                          % style for identifiers
1194
      keywordstyle=\gsfontfamily\color{gsplum},%
                                                         % color for keywords
1195
      language=Python,%
                                                         % select language
1196
1197
      linewidth=\linewidth,%
                                                         % width of listings
1198
      morekevwords={%
                                                         % VPython/GlowScript specific keywords
        __future__,abs,acos,align,ambient,angle,append,append_to_caption,%
1199
        append_to_title,arange,arrow,asin,astuple,atan,atan2,attach_arrow,%
1200
        attach_trail,autoscale,axis,background,billboard,bind,black,blue,border,%
1201
        bounding_box,box,bumpaxis,bumpmap,bumpmaps,camera,canvas,caption,capture,%
1202
        ceil,center,clear_trail,click,clone,CoffeeScript,coils,color,combin,%
1203
        comp, compound, cone, convex, cos, cross, curve, cyan, cylinder, data, degrees, del, %
1204
        delete, depth, descender, diff_angle, digits, division, dot, draw_complete, %
1205
        ellipsoid, emissive, end_face_color, equals, explog, extrusion, faces, factorial, %
1206
        False, floor, follow, font, format, forward, fov, frame, gcurve, gdisplay, gdots, %
1207
        get_library,get_selected,ghbars,global,GlowScript,graph,graphs,green,gvbars,%
1208
        hat, headlength, headwidth, height, helix, hsv_to_rgb, index, interval, keydown, %
1209
1210
        keyup, label, length, lights, line, linecolor, linewidth, logx, logy, lower left, %
        lower right, mag, mag2, magenta, make trail, marker_color, markers, material, %
1211
        max,min,mouse,mousedown,mousemove,mouseup,newball,norm,normal,objects,%
1212
        offset, one, opacity, orange, origin, path, pause, pi, pixel_to_world, pixels, plot, %
1213
        points, pos, pow, pps, print, print_function, print_options, proj, purple, pyramid, %
1214
1215
        quad, radians, radius, random, rate, ray, read_local_file, readonly, red, redraw, %
        retain, rgb_to_hsv, ring, rotate, round, scene, scroll, shaftwidth, shape, shapes, %
1216
        shininess, show_end_face, show_start_face, sign, sin, size, size_units, sleep, %
1217
1218
        smooth, space, sphere, sqrt, start, start_face_color, stop, tan, text, textpos, %
        texture, textures, thickness, title, trail_color, trail_object, trail_radius, %
1219
        trail_type,triangle,trigger,True,twist,unbind,up,upper_left,upper_right,%
1220
1221
        userpan, userspin, userzoom, vec, vector, vertex, vertical_spacing, visible, %
1222
        visual, vpython, VPython, waitfor, white, width, world, xtitle, yellow, yoffset, %
1223
        ytitle%
1224
      },%
      morekeywords={print,None,TypeError},%
                                                    % additional keywords
1225
```

```
morestring=[b]{"""},%
                                                 % treat triple quotes as strings
1226
                                                 % where to put line numbers
1227
     numbers=left.%
     numbersep=10pt,%
                                                 % how far line numbers are from code
1228
     numberstyle=\bfseries\tiny,%
                                                 % set to 'none' for no line numbers
1229
     showstringspaces=false,%
                                                 % show spaces in strings
1230
     showtabs=false,%
                                                 % show tabs within strings
1231
     stringstyle=\gsfontfamily\color{gsgreen}, % % color for strings
1233 upquote=true,%
                                                  % how to typeset quotes
1234 }%
    Introduce a new, more intelligent glowscriptblock<sup>→P.64</sup> environment.
1235 \NewTCBListing[auto counter,list inside=gsprogs]{glowscriptblock}
     { O{} D(){glowscript.org} m }{%
1236
1237
     breakable,%
1238
     center,%
1239
     code = \newpage,%
1240 %derivpeach,%
1241 enhanced,%
1242 hyperurl interior = https://#2,%
1243 label = {gs:\thetcbcounter},%
1244 left = 8mm,%
1245 list entry = \thetcbcounter~~~#3,%
1246 listing only,%
1247 listing style = vpython,%
    nameref = \{#3\},%
1248
     title = \texttt{GlowScript} Program \thetcbcounter: #3,%
1249
1250
     width = 0.9\textwidth,%
1251
    {#1},
1252 }%
     A new command for generating a list of GlowScript programs.
1253 \NewDocumentCommand{\listofglowscriptprograms}{}{\tcblistof[\section*]{gsprogs}
     {List of \texttt{GlowScript} Programs}}%
    Introduce a new, more intelligent \vpythonfile \frac{1}{2} command.
1255 \NewTCBInputListing[auto counter,list inside=vpprogs]{\vpythonfile}
     { O{} m m }{%
1256
    breakable.%
1257
     center,%
1258
1259
     code = \newpage,%
1260 %derivgray,%
1261
    enhanced, %
1262 hyperurl interior = https://,%
1263 label = {vp:\thetcbcounter},%
1264 left = 8mm,%
1265 list entry = \thetcbcounter~~~#3,%
1266 listing file = {#2},%
1267 listing only,%
1268 listing style = vpython,%
     nameref = \{#3\},%
1269
     title = \texttt{VPython} Program \thetcbcounter: #3,%
1270
     width = 0.9\textwidth,%
1271
1272 {#1},%
1273 }%
     A new command for generating a list of VPython programs.
1274 \wownertCommand{\listofvpythonprograms}{}{\tcblistof[\section*]{vpprogs}}
    {List of \texttt{VPython} Programs}}%
```

Introduce a new  $\glosscriptinline^{\rightarrow P.69}$  command.

```
1276 \DeclareTotalTCBox{\glowscriptinline}{ m }{%
1277 bottom = Opt,%
1278 bottomrule = 0.0mm,%
1279 boxsep = 1.0mm,%
1280 colback = gsbggray,%
1281 colframe = gsbggray,%
1282 left = Opt,%
1283 leftrule = 0.0mm,%
1284 nobeforeafter,%
1285 right = 0pt,%
1286 rightrule = 0.0mm,%
1287 sharp corners,%
     tcbox raise base,%
1288
    top = Opt,%
1289
1290 toprule = 0.0mm,%
1291 }{\lstinline[style = vpython]{#1}}%
```

Define  $\protect\operatorname{VPythoninline}^{\to P.69}$ , a semantic alias for  $\protect\operatorname{VPython}$  in-line listings.

 $1292 \verb|\NewDocumentCommand{\vpythoninline}{}{\cline{Command}}$ 

# 5 The mandiexp Package

mandi comes with an accessory package mandiexp which includes commands specific to *Matter & Interactions.*<sup>5</sup> 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.

#### 5.1 The Fundamenal Principles

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

```
\label{lem:continuous} $$ \begin{array}{ll} \label{lem:continuous} \label{lem:continuous} \label{lem:continuous} \label{lem:continuous} \\ \label{lem:continuous} \label{lem:continuous} \label{lem:continuous} \label{lem:continuous} \\ \label{lem:continuous} \label{lem:continuous} \label{lem:continuous} \label{lem:continuous} \\ \label{lem:continuous} \labe
```

<sup>&</sup>lt;sup>5</sup>See Matter & Interactions and https://matterandinteractions.org/ for details.

```
\ensuremath{\mbox{\mbox{energyprincipleupdate}}} [\langle +process... \rangle]
```

(update form)

Variants of command for typesetting the energy principle.

```
\Delta E_{\rm sys}
                                                                           W_{\rm ext}
\( \lhsenergyprinciple \)
\( \rhsenergyprinciple \)
                                                                           W_{\rm ext} + Q
\( \rhsenergyprinciple[+Q] \)
                                                                           \Delta E_{\rm sys} = W_{\rm ext}
\Delta E_{\rm sys} = W_{\rm ext} + Q
\( \energyprinciple \)
\(\energyprinciple[+Q]\)
\(\lhsenergyprincipleupdate\)
                                                                           E_{\rm sys,final}
\(\rhsenergyprincipleupdate\)
                                                                           E_{\text{sys,initial}} + W_{\text{ext}}
\( \rhsenergyprincipleupdate[+Q] \)
                                                                           E_{\rm sys,initial} + W_{\rm 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
```

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

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

```
\begin{array}{l} \Delta \boldsymbol{L}_{A,\mathrm{sys,net}} \\ \boldsymbol{\tau}_{A,\mathrm{sys,net}} \, \Delta t \end{array}
\(\lhsangularmomentumprinciple\)
                                                                                                         oldsymbol{L}_{A,	ext{sys},	ext{final}}
\(\rhsangularmomentumprinciple\)
                                                                                   //
                                                                                                         \boldsymbol{L}_{A,\mathrm{sys,initial}} + \boldsymbol{\tau}_{A,\mathrm{sys,net}} \, \varDelta t
\(\lhsangularmomentumprincipleupdate\)
                                                                                                          \begin{split} \Delta L_{A, \text{sys, net}} &= \tau_{A, \text{sys, net}} \, \Delta t \\ L_{A, \text{sys, final}} &= L_{A, \text{sys, initial}} + \tau_{A, \text{sys, net}} \, \Delta t \end{split} 
\(\rhsangularmomentumprincipleupdate\)
                                                                                   //
\(\angularmomentumprinciple\)
                                                                                    //
\(\angularmomentumprincipleupdate \)
                                                                                   //
                                                                                                         \Delta \vec{L}_{A, \mathrm{sys, net}}
\(\lhsangularmomentumprinciple*\)
                                                                                   //
                                                                                                         \overrightarrow{\tau}_{A, \text{sys,net}} \Delta t
\(\rhsangularmomentumprinciple*\)
\(\langularmomentumprincipleupdate*\)\\
                                                                                                         \overrightarrow{L}_{A, \rm sys, final}
\( \rhsangularmomentumprincipleupdate* \)
                                                                                                         \overrightarrow{L}_{A, \rm sys, initial} + \overrightarrow{\tau}_{A, \rm sys, net} \, \Delta t
\(\angularmomentumprinciple* \)
\(\angularmomentumprincipleupdate* \)
                                                                                                         \Delta \overrightarrow{L}_{A, \rm sys, net} = \overrightarrow{\tau}_{A, \rm sys, net} \, \Delta t
                                                                                                         \overrightarrow{L}_{A, \rm sys, final} = \overrightarrow{L}_{A, \rm sys, initial} + \overrightarrow{\tau}_{A, \rm sys, net} \, \Delta t
```

# 5.2 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

#### $\symbol{systemenergy} [\langle label \rangle]$

Symbol for system energy.

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

#### N 2021-02-13

# $\texttt{\particleenergy}[\langle label \rangle]$

Symbol for particle energy.

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

#### N 2021-02-13

# 

Symbol for rest energy.

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

#### N 2021-02-13

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

Symbol for internal energy.

<pre>\( \internalenergy \) \\ \( \internalenergy[\symup{final}] \)</pre>
--

#### N 2021-02-13

#### $\verb|\chemicalenergy[|\langle label\rangle|]|$

Symbol for chemical energy.

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

#### N 2021-02-13

#### $\text{ \text{ } \text{ \text{ \text{ }}} } [\langle label angle] }$

Symbol for thermal energy.

N 2021-02-13

#### \photonenergy [ $\langle label \rangle$ ]

Symbol for photon energy.

```
\( \photonenergy \) \\ \( \photonenergy[\symup{final}] \) E_{\rm photon,final}
```

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

```
\translationalkineticenergy [\langle label \rangle] \translationalkineticenergy*[\langle label \rangle]
```

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

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

# \rotationalkineticenergy [ $\langle label \rangle$ ] \rotationalkineticenergy\* [ $\langle label \rangle$ ]

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

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

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

N 2021-02-13

#### \gravitationalpotentialenergy [ $\langle label \rangle$ ]

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$}}} \ensuremath{\mbox{\mbox{\mbox{$\sim$}}} \ensuremath{\mbox{\mbox{$\sim$}}} \ensuremath{\mbox{$\sim$}} \ensuremath{\mbox{\mbox{$\sim$}}} \ensuremath{\mbox{\mbox{$\sim$}}} \ensuremath{\mbox{$\sim$}} \ensu$

Symbol for electric potential energy.

<pre>\( \electricpotentialenergy \) \\ \( \electricpotentialenergy[\symup{final}] \)</pre>	$U_{ m e} \ U_{ m e,final}$
--	-----------------------------

#### N 2021-02-13

# $\verb|\springpotentialenergy[|\langle label\rangle||$

Symbol for spring potential energy.

|--|

# 5.3 mandiexp 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.

```
1293 \def\mandiexp@Version{3.0.0m}
1294 \def\mandiexp@Date{2021-06-13}
1295 \NeedsTeXFormat{LaTeX2e} [1999/12/01]
1296 \providecommand\DeclareRelease[3]{}
1297 \providecommand\DeclareCurrentRelease[2]{}
1298 \DeclareRelease{v3.0.0m}{2021-06-13}{mandiexp.sty}
1299 \DeclareCurrentRelease{v\mandiexp@Version}{\mandiexp@Date}
1300 \ProvidesPackage{mandiexp}
      [\mandiexp@Date\space v\mandiexp@Version\space Macros for Matter & Interactions]
     Define a convenient package version command.
1302 \newcommand*{\mandiexpversion}{v\mandiexp@Version\space dated \mandiexp@Date}
1303 \RequirePackage{mandi}
1304 %
1305 \typeout{}%
1306 \typeout{mandiexp: You are using mandiexp \mandiexpversion.}
1307 \typeout{mandiexp: This package requires LuaLaTeX.}%
1308 \text{typeout}{}\%
1309 %
1310 % Commands specific to Matter & Interactions
1311 % The momentum principle
1312 \NewDocumentCommand{\lhsmomentumprinciple}{ s }{%
1313
      \Delta
      \IfBooleanTF{#1}%
1314
        {\text{vec}*{p}}%
1315
1316
        {\vec{p}}}%
      _{\symup{sys}}%
1317
1318 }%
1319 \NewDocumentCommand{\rhsmomentumprinciple}{ s }{%
1320
      \IfBooleanTF{#1}%
1321
        {\vec*{F}}%
1322
        {\text{vec}{F}}%
      _{\symup{sys,net}}\,\Delta t%
1325 \NewDocumentCommand{\lhsmomentumprincipleupdate}{ s }{%
      \IfBooleanTF{#1}%
1326
        {\vec*{p}}%
1327
        {\text{vec}\{p\}}%
1328
1329
      _{\symup{sys,final}}%
1330 }%
1331 \NewDocumentCommand{\rhsmomentumprincipleupdate}{ s }{%
1332
      \IfBooleanTF{#1}%
1333
        {\vec*{p}}%
1334
        {\vec{p}}}%
1335
      _{\text{symup{sys,initial}}+\%}
      \IfBooleanTF{#1}%
1336
        {\text{vec}*{F}}%
1337
        {\text{vec}{F}}%
1338
      _{\symup{sys,net}}\,\Delta t%
1339
1340 }%
1341 \NewDocumentCommand{\momentumprinciple}{ s }{%
      \IfBooleanTF{#1}%
1342
        {\lhsmomentumprinciple* = \rhsmomentumprinciple*}%
1343
```

```
{\lhsmomentumprinciple = \rhsmomentumprinciple}%
1344
1345 }%
1346 \NewDocumentCommand{\momentumprincipleupdate}{ s }{%
      \IfBooleanTF{#1}%
1347
        {\lhsmomentumprincipleupdate* = \rhsmomentumprincipleupdate*}%
1348
1349
        {\lhsmomentumprincipleupdate = \rhsmomentumprincipleupdate}%
1350 }%
1351 % The momentum principle
1352 \NewDocumentCommand{\lhsenergyprinciple}{}{%
      \Delta E_{\symup{sys}}%
1354 }%
1355 \NewDocumentCommand{\rhsenergyprinciple}{ O{} }{%
1356
      W_{\symup{ext}}#1%
1357 }%
1358 \NewDocumentCommand{\lhsenergyprincipleupdate}{}{%
      E_{\symup{sys,final}}%
1359
1360 }%
1361 \NewDocumentCommand{\rhsenergyprincipleupdate}{ 0{} }{%
      E_{\symup{sys,initial}}+%
      W_{\symup{ext}}#1%
1364 }%
1365 \NewDocumentCommand{\energyprinciple}{ O{} }{%
      \lhsenergyprinciple = \rhsenergyprinciple[#1]%
1366
1367 }%
1368 \NewDocumentCommand{\energyprincipleupdate}{ O{} }{%
1369
      \lhsenergyprincipleupdate = \rhsenergyprincipleupdate[#1]%
1370 }%
1371 % The angular momentum principle
1372 \NewDocumentCommand{\lhsangularmomentumprinciple}{ s }{%
1373
      \Delta
      \IfBooleanTF{#1}%
1374
1375
        {\text{\vec}*\{L\}}%
        {\vec{L}}%
1376
      _{A\symup{,sys,net}}%
1377
1378 }%
1379 \NewDocumentCommand{\rhsangularmomentumprinciple}{ s }{\%}
      \IfBooleanTF{#1}%
1380
        {\text{vec*}}
1381
        {\text{vec}}
1382
      _{A\symup{,sys,net}}\,\Delta t%
1383
1384 }%
1385 \NewDocumentCommand{\lhsangularmomentumprincipleupdate}{ s }{%
1386
      \IfBooleanTF{#1}%
        {\vec*{L}}%
1387
        {\text{vec}\{L\}}%
1388
1389
      _{A,\symup{sys,final}}%
1390 }%
1391 \NewDocumentCommand{\rhsangularmomentumprincipleupdate}{ s }{%
      \IfBooleanTF{#1}%
1392
        {\vec*{L}}}%
1393
        {\vec{L}}%
1394
      _{A\symup{,sys,initial}}+%
1395
      \IfBooleanTF{#1}%
1396
        {\text{vec}*{\hat{}}}
1397
1398
        {\text{vec}}
      _{A\symup{,sys,net}}\,\Delta t%
1399
1400 }%
1401 \NewDocumentCommand{\angularmomentumprinciple}{ s }{%
      \IfBooleanTF{#1}%
```

```
{\lhsangularmomentumprinciple* = \rhsangularmomentumprinciple*}%
1403
                          {\lhsangularmomentumprinciple = \rhsangularmomentumprinciple}%
1404
1405 }%
1406 \NewDocumentCommand{\angularmomentumprincipleupdate}{ s }{\%}
                  \IfBooleanTF{#1}%
1407
                          {\lhsangularmomentumprincipleupdate* = \rhsangularmomentumprincipleupdate*}%
1408
                          {\lhsangularmomentumprincipleupdate = \rhsangularmomentumprincipleupdate}%
1410 }%
1411 \NewDocumentCommand{\energyof}{ m o }{%
1412 E_{#1\IfValueT{#2}{,#2}}%
1413 }%
1414 \NewDocumentCommand{\systemenergy}{ o }{%
1415
               E_{\scriptstyle \} \
1416 }%
1417 \NewDocumentCommand{\particleenergy}{ o }{%
                E_{\symup{particle}\IfValueT{#1}{,#1}}%
1419 }%
1420 \NewDocumentCommand{\restenergy}{ o }{%
1421
                  1422 }%
1423 \NewDocumentCommand{\internalenergy}{ o }{%
                  1425 }%
1426 \NewDocumentCommand{\chemicalenergy}{ o }{%
                  1427
1428 }%
1429 \NewDocumentCommand{\thermalenergy}{ o }{%
                  1430
1431 }%
1432   \NewDocumentCommand{\photonenergy}{ o }{\%}
                  E_{\scriptstyle \} E_{\scriptstyle
1434 }%
1435 \NewDocumentCommand{\translationalkineticenergy}{ s d[] }{%
1436 % d[] must be used because of the way consecutive optional
1437 % arguments are handled. See xparse docs for details.
1438 % See https://tex.stackexchange.com/a/569011/218142
                  \IfBooleanTF{#1}%
1439
                   {E_\bgroup \symup{K}}%
1440
                   {K_\bgroup\symup{trans}}%
1441
                                    \If ValueT{#2}{,#2}%
1442
1443
                             \egroup%
1444 }%
1445 \NewDocumentCommand{\rotationalkineticenergy}{ s d[] }{%
1446 \% d[] must be used because of the way consecutive optional
1447 \% arguments are handled. See xparse docs for details.
1448 % See https://tex.stackexchange.com/a/569011/218142
                  \IfBooleanTF{#1}%
1449
1450
                  {E_\bgroup}%
                   {K_\bgroup}%
1451
                                   \symup{rot}\IfValueT{#2}{,#2}%
1452
                             \egroup%
1453
1454 }%
1455 \NewDocumentCommand{\vibrationalkineticenergy}{ s d[] }{%
1456 % d[] must be used because of the way consecutive optional
                     arguments are handled. See xparse docs for details.
1458 % See https://tex.stackexchange.com/a/569011/218142
                  \IfBooleanTF{#1}%
1459
                  {E_\bgroup}%
1460
1461
                  {K_\bgroup}%
```

```
1462 \symup{vib}\IfValueT{#2}{,#2}%
1463 \egroup%
1464 }%
1465 \NewDocumentCommand{\gravitationalpotentialenergy}{ o }{%
1466 U_{\symup{g}\IfValueT{#1}{,#1}}%
1467 }%
1468 \NewDocumentCommand{\electricpotentialenergy}{ o }{%
1469 U_{\symup{e}\IfValueT{#1}{,#1}}%
1470 }%
1471 \NewDocumentCommand{\springpotentialenergy}{ o }{%
1472 U_{\symup{s}\IfValueT{#1}{,#1}}%
1473 }%
```

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