

# The [mandi](#) Bundle

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**PLEASE DO NOT DISTRIBUTE THIS VERSION.**

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To all of the students who have learned  $\text{\LaTeX}$  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  $\text{\LaTeX}$  developers who inhabit the [TeX StackExchange](#) site. Entering a new culture is daunting for anyone, especially for newcomers. The  $\text{\LaTeX}$  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, 52, 78

## List of GlowScript Programs

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# 1 Introduction

The `mandi`<sup>1</sup> bundle consists of three packages: `mandi`, `mandistudent`, and `mandiexp`. Package `mandi`<sup>→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>→P.52</sup> provides other typesetting capability appropriate for written problem solutions. Finally, package `mandiexp`<sup>→P.78</sup> provides commands for typesetting expressions from *Matter & Interactions*<sup>2</sup>

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<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>See *Matter & Interactions* and <https://matterandinteractions.org/> for details.

## 2 Student/Instructor Quick Guide

Use `\vec`<sup>P.52</sup> to typeset the symbol for a vector. Use `\magnitude`<sup>P.55</sup> to typeset the symbol for a vector's magnitude. Use `\dirvec`<sup>P.52</sup> to typeset the symbol for a vector's direction. Use `\changein`<sup>P.53</sup> to typeset the symbol for the change in a vector or scalar. Use `\zerovec`<sup>P.52</sup> to typeset the zero vector. Use `\timestento`<sup>P.36</sup> to typeset scientific notation.

```
\( \vec{p} ) or \( \vec{*p} ) \\
\(\ \vec{p}_{\mathrm{final}} ) or \( \vec{*p}_{\mathrm{final}} ) \\
\(\ \mathrm{magnitude}\{\vec{p}\} ) or \( \mathrm{magnitude*}\{\vec{p}_{\mathrm{final}}\} ) \\
\(\ \mathrm{dirvec}\{p\} ) or \( \mathrm{dirvec*}\{p\} ) \\
\(\ \mathrm{changein}\ \vec{p} ) or \( \mathrm{changein}\ t ) \\
\(\ \zerovec ) or \( \zerovec* ) \\
\(\ 6.02\timestento{-19} )
```

$p$  or  $\vec{p}$   
 $p_{\mathrm{final}}$  or  $\vec{p}_{\mathrm{final}}$   
 $\|p\|$  or  $\|p_{\mathrm{final}}\|$   
 $\hat{p}$  or  $\widehat{p}$   
 $\Delta p$  or  $\Delta t$   
 $\mathbf{0}$  or  $\vec{0}$   
 $6.02 \times 10^{-19}$

Use a `physical quantity's`<sup>P.9</sup> 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`<sup>P.9</sup> and its variants.

```
\( \momentum{7.071} ) \\
\(\ \vectormomentum{3,-4,5} ) \\
\(\ \momentumvector{3,-4,5} )
```

7.071 kg · m/s  
 $\langle 3, -4, 5 \rangle$  kg · m/s  
 $\langle 3, -4, 5 \rangle$  kg · m/s

Use a `physical constant's`<sup>P.25</sup> 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`<sup>P.32</sup> and its variant.

```
\( \vacuumpermittivitymathsymbol = \vacuumpermittivity )
```

$\epsilon_0 = 9 \times 10^{-12} \text{C}^2/\text{N} \cdot \text{m}^2$

Use `\mivector`<sup>P.37</sup> to typeset symbolic vectors with components. Use the aliases `\direction`<sup>P.53</sup> or `\unitvector`<sup>P.53</sup> to typeset a direction or unit vector.

```
\( \mivector{\slot,\slot,\slot} ) or \( \mivector{p_x,p_y,p_z} ) \\
\(\ \direction{\frac{1}{\sqrt{3}},\frac{1}{\sqrt{3}},\frac{1}{\sqrt{3}}} ) or \\
\(\ \unitvector{\frac{1}{\sqrt{3}},\frac{1}{\sqrt{3}},\frac{1}{\sqrt{3}}} )
```

$\langle \_, \_, \_ \rangle$  or  $\langle p_x, p_y, p_z \rangle$   
 $\left\langle \frac{1}{\sqrt{3}}, \frac{1}{\sqrt{3}}, \frac{1}{\sqrt{3}} \right\rangle$  or  $\left\langle \frac{1}{\sqrt{3}}, \frac{1}{\sqrt{3}}, \frac{1}{\sqrt{3}} \right\rangle$

Use `physicsproblem`<sup>P.55</sup> and `parts`<sup>P.55</sup> and `\problem part`<sup>P.56</sup> for problems. For step-by-step mathematical solutions use `physicssolution`<sup>P.57</sup>. Use `glowscripblock`<sup>P.62</sup> to typeset **GlowScript** programs. Use `\vpythonfile`<sup>P.65</sup> to typeset **VPython** program 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 2021-05-28 and is a stable build.

#### 3.1 Package Options

N 2021-01-30

**units**=*<type of unit>* (initially unspecified, set to **alternate**)

N 2021-01-30

**preciseconstants**=*<boolean>* (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 **mandisetaup** Command

N 2021-02-17

**\mandisetaup**{*<options>*}

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

```
\mandisetaup{units=base}
```

```
\mandisetaup{preciseconstants}
```

```
\mandisetaup{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.

**`\momentum`** $\{\langle magnitude \rangle\}$   
**`\momentumvector`** $\{\langle c_1, \dots, c_n \rangle\}$   
**`\vectormomentum`** $\{\langle c_1, \dots, c_n \rangle\}$

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.

<code>\momentum{5}</code>	<code>\%</code>	$5 \text{ kg} \cdot \text{m/s}$
<code>\momentumvalue{5}</code>	<code>\%</code>	$5$
<code>\momentumbaseunits{5}</code>	<code>\%</code>	$5 \text{ kg} \cdot \text{m} \cdot \text{s}^{-1}$
<code>\momentumderivedunits{5}</code>	<code>\%</code>	$5 \text{ kg} \cdot \text{m/s}$
<code>\momentumalternateunits{5}</code>	<code>\%</code>	$5 \text{ kg} \cdot \text{m/s}$
<code>\vectormomentum{2,3,4}</code>	<code>\%</code>	$\langle 2, 3, 4 \rangle \text{ kg} \cdot \text{m/s}$
<code>\momentumvector{2,3,4}</code>	<code>\%</code>	$\langle 2, 3, 4 \rangle \text{ kg} \cdot \text{m/s}$
<code>\momentum{\mivector{2,3,4}}</code>	<code>\%</code>	$\langle 2, 3, 4 \rangle \text{ kg} \cdot \text{m/s}$
<code>\momentumonlybaseunits</code>	<code>\%</code>	$\text{kg} \cdot \text{m} \cdot \text{s}^{-1}$
<code>\momentumonlyderivedunits</code>	<code>\%</code>	$\text{kg} \cdot \text{m/s}$
<code>\momentumonlyalternateunits</code>	<code>\%</code>	$\text{kg} \cdot \text{m/s}$

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

The vector variants do not have special variants that isolate units because that would be redundant. A vector and its magnitude have the same unit.

#### 3.3.2 Checking Physical Quantities

**`\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`<sup>P.37</sup> instead.

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	
$\text{m} \cdot \text{s}^{-2}$	N/kg	$\text{m/s}^2$	

**\amount** $\{\langle magnitude \rangle\}$

name			
\amount			
base	derived	alternate	
mol	mol	mol	

N 2021-02-24

**\angularacceleration** $\{\langle magnitude \rangle\}$   
**\angularaccelerationvector** $\{\langle c_1, \dots, c_n \rangle\}$   
**\vectorangularacceleration** $\{\langle c_1, \dots, c_n \rangle\}$

name			
\angularacceleration			
base	derived	alternate	
$\text{rad} \cdot \text{s}^{-2}$	$\text{rad/s}^2$	$\text{rad/s}^2$	

**\angularfrequency** $\{\langle magnitude \rangle\}$

name			
\angularfrequency			
base	derived	alternate	
$\text{rad} \cdot \text{s}^{-1}$	rad/s	rad/s	

N 2021-02-24

**\angularimpulse** $\{\langle magnitude \rangle\}$   
**\angularimpulsevector** $\{\langle c_1, \dots, c_n \rangle\}$   
**\vectorangularimpulse** $\{\langle c_1, \dots, c_n \rangle\}$

name			
\angularimpulse			
base	derived	alternate	
$\text{kg} \cdot \text{m}^2 \cdot \text{s}^{-1}$	$\text{kg} \cdot \text{m}^2/\text{s}$	$\text{kg} \cdot \text{m}^2/\text{s}$	

N 2021-02-24

**\angularmomentum** $\{\langle magnitude \rangle\}$   
**\angularmomentumvector** $\{\langle c_1, \dots, c_n \rangle\}$   
**\vectorangularmomentum** $\{\langle c_1, \dots, c_n \rangle\}$

name			
\angularmomentum			
base	derived	alternate	
$\text{kg} \cdot \text{m}^2 \cdot \text{s}^{-1}$	$\text{kg} \cdot \text{m}^2/\text{s}$	$\text{kg} \cdot \text{m}^2/\text{s}$	

\angularvelocity{\langle magnitude \rangle}  
 \angularvelocityvector{\langle c\_1, \dots, c\_n \rangle}  
 \vectorangularvelocity{\langle c\_1, \dots, c\_n \rangle}

name			
\angularvelocity			
base	derived	alternate	
$\text{rad} \cdot \text{s}^{-1}$	$\text{rad}/\text{s}$	$\text{rad}/\text{s}$	

\area{\langle magnitude \rangle}

name			
\area			
base	derived	alternate	
$\text{m}^2$	$\text{m}^2$	$\text{m}^2$	

\areachargedensity{\langle magnitude \rangle}

name			
\areachargedensity			
base	derived	alternate	
$\text{A} \cdot \text{s} \cdot \text{m}^{-2}$	$\text{C}/\text{m}^2$	$\text{C}/\text{m}^2$	

\areamassdensity{\langle magnitude \rangle}

name			
\areamassdensity			
base	derived	alternate	
$\text{kg} \cdot \text{m}^{-2}$	$\text{kg}/\text{m}^2$	$\text{kg}/\text{m}^2$	

\capacitance{\langle magnitude \rangle}

name			
\capacitance			
base	derived	alternate	
$\text{A}^2 \cdot \text{s}^4 \cdot \text{kg}^{-1} \cdot \text{m}^{-2}$	$\text{F}$	$\text{C}/\text{V}$	

\charge{\langle magnitude \rangle}

name			
\charge			
base	derived	alternate	
$\text{A} \cdot \text{s}$	$\text{C}$	$\text{C}$	

**\cmagneticfield**{ $\langle magnitude \rangle$ }  
**\cmagneticfieldvector**{ $\langle c_1, \dots, c_n \rangle$ }  
**\vectorcmagneticfield**{ $\langle c_1, \dots, c_n \rangle$ }

name			
\cmagneticfield			
base	derived	alternate	
$\text{kg} \cdot \text{m} \cdot \text{A}^{-1} \cdot \text{s}^{-3}$	N/C	N/C	

**\conductance**{ $\langle magnitude \rangle$ }

name			
\conductance			
base	derived	alternate	
$\text{A}^2 \cdot \text{s}^3 \cdot \text{kg}^{-1} \cdot \text{m}^{-2}$	S	A/V	

**\conductivity**{ $\langle magnitude \rangle$ }

name			
\conductivity			
base	derived	alternate	
$\text{A}^2 \cdot \text{s}^3 \cdot \text{kg}^{-1} \cdot \text{m}^{-3}$	S/m	A/V · m	

**\conventionalcurrent**{ $\langle magnitude \rangle$ }

name			
\conventionalcurrent			
base	derived	alternate	
A	C/s	A	

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

name			
\current			
base	derived	alternate	
A	A	A	

**\currentdensity**{ $\langle magnitude \rangle$ }  
**\currentdensityvector**{ $\langle c_1, \dots, c_n \rangle$ }  
**\vectorcurrentdensity**{ $\langle c_1, \dots, c_n \rangle$ }

name			
\currentdensity			
base	derived	alternate	
$\text{A} \cdot \text{m}^{-2}$	C/s · m <sup>2</sup>	A/m <sup>2</sup>	

**\dielectricconstant** $\{\langle magnitude \rangle\}$

**name**

**\dielectricconstant**

base

derived

alternate

**\displacement** $\{\langle magnitude \rangle\}$

**\displacementvector** $\{\langle c_1, \dots, c_n \rangle\}$

**\vectordisplacement** $\{\langle c_1, \dots, c_n \rangle\}$

**name**

**\displacement**

base

derived

alternate

m

m

m

**\duration** $\{\langle magnitude \rangle\}$

**name**

**\duration**

base

derived

alternate

s

s

s

**\electricdipolemoment** $\{\langle magnitude \rangle\}$

**\electricdipolemomentvector** $\{\langle c_1, \dots, c_n \rangle\}$

**\vectorelectricdipolemoment** $\{\langle c_1, \dots, c_n \rangle\}$

**name**

**\electricdipolemoment**

base

derived

alternate

A · s · m

C · m

C · m

**\electricfield** $\{\langle magnitude \rangle\}$

**\electricfieldvector** $\{\langle c_1, \dots, c_n \rangle\}$

**\vectorelectricfield** $\{\langle c_1, \dots, c_n \rangle\}$

**name**

**\electricfield**

base

derived

alternate

kg · m · A<sup>-1</sup> · s<sup>-3</sup>

V/m

N/C

**\electricflux** $\{\langle magnitude \rangle\}$

**name**

**\electricflux**

base

derived

alternate

kg · m<sup>3</sup> · A<sup>-1</sup> · s<sup>-3</sup>

V · m

N · m<sup>2</sup>/C

**`\electricpotential`** $\{\langle magnitude \rangle\}$

**name**

`\electricpotential`

base

$\text{kg} \cdot \text{m}^2 \cdot \text{A}^{-1} \cdot \text{s}^{-3}$

derived

V

alternate

V

N 2021-05-01

**`\electricpotentialdifference`** $\{\langle magnitude \rangle\}$

**name**

`\electricpotentialdifference`

base

$\text{kg} \cdot \text{m}^2 \cdot \text{A}^{-1} \cdot \text{s}^{-3}$

derived

V

alternate

V

**`\electroncurrent`** $\{\langle magnitude \rangle\}$

**name**

`\electroncurrent`

base

$\text{s}^{-1}$

derived

e/s

alternate

e/s

**`\emf`** $\{\langle magnitude \rangle\}$

**name**

`\emf`

base

$\text{kg} \cdot \text{m}^2 \cdot \text{A}^{-1} \cdot \text{s}^{-3}$

derived

V

alternate

V

**`\energy`** $\{\langle magnitude \rangle\}$

**name**

`\energy`

base

$\text{kg} \cdot \text{m}^2 \cdot \text{s}^{-2}$

derived

J

alternate

J

N 2021-04-15

**`\energyinev`** $\{\langle magnitude \rangle\}$

**name**

`\energyinev`

base

eV

derived

eV

alternate

eV

N 2021-04-15

**`\energyinkev`** $\{\langle magnitude \rangle\}$

**name**

`\energyinkev`

base

keV

derived

keV

alternate

keV

N 2021-04-15

**\energyinmev** $\{\langle magnitude \rangle\}$

name			
\energyinmev			
base	derived	alternate	
MeV	MeV	MeV	

**\energydensity** $\{\langle magnitude \rangle\}$

name			
\energydensity			
base	derived	alternate	
$\text{kg} \cdot \text{m}^{-1} \cdot \text{s}^{-2}$	$\text{J}/\text{m}^3$	$\text{J}/\text{m}^3$	

N 2021-02-24

**\energyflux** $\{\langle magnitude \rangle\}$

**\energyfluxvector** $\{\langle c_1, \dots, c_n \rangle\}$

**\vectorenergyflux** $\{\langle c_1, \dots, c_n \rangle\}$

name			
\energyflux			
base	derived	alternate	
$\text{kg} \cdot \text{s}^{-3}$	$\text{W}/\text{m}^2$	$\text{W}/\text{m}^2$	

**\entropy** $\{\langle magnitude \rangle\}$

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

N 2021-02-24

**\force** $\{\langle magnitude \rangle\}$

**\forcevector** $\{\langle c_1, \dots, c_n \rangle\}$

**\vectorforce** $\{\langle c_1, \dots, c_n \rangle\}$

name			
\force			
base	derived	alternate	
$\text{kg} \cdot \text{m} \cdot \text{s}^{-2}$	N	N	

**\frequency** $\{\langle magnitude \rangle\}$

name			
\frequency			
base	derived	alternate	
$\text{s}^{-1}$	Hz	Hz	

N 2021-02-24

**\gravitationalfield** $\{\langle magnitude \rangle\}$   
**\gravitationalfieldvector** $\{\langle c_1, \dots, c_n \rangle\}$   
**\vectorgravitationalfield** $\{\langle c_1, \dots, c_n \rangle\}$

name			
\gravitationalfield			
base	derived	alternate	
$\text{m} \cdot \text{s}^{-2}$	N/kg	N/kg	

**\gravitationalpotential** $\{\langle magnitude \rangle\}$

name			
\gravitationalpotential			
base	derived	alternate	
$\text{m}^2 \cdot \text{s}^{-2}$	J/kg	J/kg	

N 2021-05-01

**\gravitationalpotentialdifference** $\{\langle magnitude \rangle\}$

name			
\gravitationalpotentialdifference			
base	derived	alternate	
$\text{m}^2 \cdot \text{s}^{-2}$	J/kg	J/kg	

N 2021-02-24

**\impulse** $\{\langle magnitude \rangle\}$   
**\impulsevector** $\{\langle c_1, \dots, c_n \rangle\}$   
**\vectorimpulse** $\{\langle c_1, \dots, c_n \rangle\}$

name			
\impulse			
base	derived	alternate	
$\text{kg} \cdot \text{m} \cdot \text{s}^{-1}$	N · s	N · s	

**\indexofrefraction** $\{\langle magnitude \rangle\}$

name			
\indexofrefraction			
base	derived	alternate	

**\inductance** $\{\langle magnitude \rangle\}$

name			
\inductance			
base	derived	alternate	
$\text{kg} \cdot \text{m}^2 \cdot \text{A}^{-2} \cdot \text{s}^{-2}$	H	V · s/A	



**\linearchargedensity** $\{\langle magnitude \rangle\}$

name			
\linearchargedensity			
base	derived	alternate	
$A \cdot s \cdot m^{-1}$	C/m	C/m	

**\linearmassdensity** $\{\langle magnitude \rangle\}$

name			
\linearmassdensity			
base	derived	alternate	
$kg \cdot m^{-1}$	kg/m	kg/m	

U 2021-05-02

**\luminousintensity** $\{\langle magnitude \rangle\}$

name			
\luminousintensity			
base	derived	alternate	
cd	cd	cd	

**\magneticcharge** $\{\langle magnitude \rangle\}$

name			
\magneticcharge			
base	derived	alternate	
$A \cdot m$	$A \cdot m$	$A \cdot m$	

N 2021-02-24

**\magneticdipolemoment** $\{\langle magnitude \rangle\}$   
**\magneticdipolemomentvector** $\{\langle c_1, \dots, c_n \rangle\}$   
**\vectormagneticdipolemoment** $\{\langle c_1, \dots, c_n \rangle\}$

name			
\magneticdipolemoment			
base	derived	alternate	
$A \cdot m^2$	$A \cdot m^2$	J/T	

N 2021-02-24

**\magneticfield** $\{\langle magnitude \rangle\}$   
**\magneticfieldvector** $\{\langle c_1, \dots, c_n \rangle\}$   
**\vectormagneticfield** $\{\langle c_1, \dots, c_n \rangle\}$

name			
\magneticfield			
base	derived	alternate	
$kg \cdot A^{-1} \cdot s^{-2}$	N/A · m	T	

**\magneticflux**{ $\langle magnitude \rangle$ }

name			
\magneticflux			
base	derived	alternate	
$\text{kg} \cdot \text{m}^2 \cdot \text{A}^{-1} \cdot \text{s}^{-2}$	$\text{T} \cdot \text{m}^2$	$\text{V} \cdot \text{s}$	

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

name			
\mass			
base	derived	alternate	
kg	kg	kg	

**\mobility**{ $\langle magnitude \rangle$ }

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

**\momentofinertia**{ $\langle magnitude \rangle$ }

name			
\momentofinertia			
base	derived	alternate	
$\text{kg} \cdot \text{m}^2$	$\text{J} \cdot \text{s}^2$	$\text{kg} \cdot \text{m}^2$	

**\momentum**{ $\langle magnitude \rangle$ }

**\momentumvectordemo**{ $\langle c_1, \dots, c_n \rangle$ }

**\vectormomentum**{ $\langle c_1, \dots, c_n \rangle$ }

name			
\momentum			
base	derived	alternate	
$\text{kg} \cdot \text{m} \cdot \text{s}^{-1}$	$\text{kg} \cdot \text{m}/\text{s}$	$\text{kg} \cdot \text{m}/\text{s}$	

**\momentumflux**{ $\langle magnitude \rangle$ }

**\momentumfluxvector**{ $\langle c_1, \dots, c_n \rangle$ }

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

name			
\momentumflux			
base	derived	alternate	
$\text{kg} \cdot \text{m}^{-1} \cdot \text{s}^{-2}$	$\text{N}/\text{m}^2$	$\text{N}/\text{m}^2$	

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**\numberdensity**{ $\langle magnitude \rangle$ }

**name**

**\numberdensity**

base

$\text{m}^{-3}$

derived

$/\text{m}^3$

alternate

$/\text{m}^3$

**\permeability**{ $\langle magnitude \rangle$ }

**name**

**\permeability**

base

$\text{kg} \cdot \text{m} \cdot \text{A}^{-2} \cdot \text{s}^{-2}$

derived

H/m

alternate

T · m/A

**\permittivity**{ $\langle magnitude \rangle$ }

**name**

**\permittivity**

base

$\text{A}^2 \cdot \text{s}^4 \cdot \text{kg}^{-1} \cdot \text{m}^{-3}$

derived

F/m

alternate

$\text{C}^2/\text{N} \cdot \text{m}^2$

**\planeangle**{ $\langle magnitude \rangle$ }

**name**

**\planeangle**

base

$\text{m} \cdot \text{m}^{-1}$

derived

rad

alternate

rad

**\polarizability**{ $\langle magnitude \rangle$ }

**name**

**\polarizability**

base

$\text{A}^2 \cdot \text{s}^4 \cdot \text{kg}^{-1}$

derived

$\text{C} \cdot \text{m}^2/\text{V}$

alternate

$\text{C}^2 \cdot \text{m}/\text{N}$

**\power**{ $\langle magnitude \rangle$ }

**name**

**\power**

base

$\text{kg} \cdot \text{m}^2 \cdot \text{s}^{-3}$

derived

W

alternate

J/s

**\poynting**{ $\langle magnitude \rangle$ }

**\poyntingvector**{ $\langle c_1, \dots, c_n \rangle$ }

**\vectorpoynting**{ $\langle c_1, \dots, c_n \rangle$ }

name			
\poynting			
base	derived	alternate	
$\text{kg} \cdot \text{s}^{-3}$	$\text{W}/\text{m}^2$	$\text{W}/\text{m}^2$	

**\pressure**{*\langle magnitude \rangle*}

name			
\pressure			
base	derived	alternate	
$\text{kg} \cdot \text{m}^{-1} \cdot \text{s}^{-2}$	Pa	$\text{N}/\text{m}^2$	

**\relativepermeability**{*\langle magnitude \rangle*}

name			
\relativepermeability			
base	derived	alternate	

**\relativepermittivity**{*\langle magnitude \rangle*}

name			
\relativepermittivity			
base	derived	alternate	

**\resistance**{*\langle magnitude \rangle*}

name			
\resistance			
base	derived	alternate	
$\text{kg} \cdot \text{m}^2 \cdot \text{A}^{-2} \cdot \text{s}^{-3}$	$\Omega$	$\Omega$	

**\resistivity**{*\langle magnitude \rangle*}

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

**\solidangle**{*\langle magnitude \rangle*}

name			
\solidangle			
base	derived	alternate	
$\text{m}^2 \cdot \text{m}^{-2}$	sr	sr	

**\specificheatcapacity**{ $\langle magnitude \rangle$ }

**name**

**\specificheatcapacity**

base

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

derived

$\text{J/K} \cdot \text{kg}$

alternate

$\text{J/K} \cdot \text{kg}$

**\springstiffness**{ $\langle magnitude \rangle$ }

**name**

**\springstiffness**

base

$\text{kg} \cdot \text{s}^{-2}$

derived

$\text{N/m}$

alternate

$\text{N/m}$

**\springstretch**{ $\langle magnitude \rangle$ }

**name**

**\springstretch**

base

$\text{m}$

derived

$\text{m}$

alternate

$\text{m}$

**\stress**{ $\langle magnitude \rangle$ }

**name**

**\stress**

base

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

derived

$\text{Pa}$

alternate

$\text{N/m}^2$

**\strain**{ $\langle magnitude \rangle$ }

**name**

**\strain**

base

derived

alternate

**\temperature**{ $\langle magnitude \rangle$ }

**name**

**\temperature**

base

$\text{K}$

derived

$\text{K}$

alternate

$\text{K}$

**\torque**{ $\langle magnitude \rangle$ }

**\torquevector**{ $\langle c_1, \dots, c_n \rangle$ }

**\vectortorque**{ $\langle c_1, \dots, c_n \rangle$ }

name			
\torque			
base	derived	alternate	
$\text{kg} \cdot \text{m}^2 \cdot \text{s}^{-2}$	$\text{N} \cdot \text{m}$	$\text{N} \cdot \text{m}$	

$\backslash\text{velocity}\{\langle\text{magnitude}\rangle\}$   
 $\backslash\text{velocityvector}\{\langle c_1, \dots, c_n \rangle\}$   
 $\backslash\text{vectorvelocity}\{\langle c_1, \dots, c_n \rangle\}$   
 $\backslash\text{velocityc}\{\langle\text{magnitude}\rangle\}$   
 $\backslash\text{velocitycvector}\{\langle c_1, \dots, c_n \rangle\}$   
 $\backslash\text{vectorvelocityc}\{\langle c_1, \dots, c_n \rangle\}$

name			
\velocity			
base	derived	alternate	
$\text{m} \cdot \text{s}^{-1}$	$\text{m/s}$	$\text{m/s}$	

name			
\velocityc			
base	derived	alternate	
c	c	c	

$\backslash\text{volume}\{\langle\text{magnitude}\rangle\}$

name			
\volume			
base	derived	alternate	
$\text{m}^3$	$\text{m}^3$	$\text{m}^3$	

$\backslash\text{volumechargedensity}\{\langle\text{magnitude}\rangle\}$

name			
\volumechargedensity			
base	derived	alternate	
$\text{A} \cdot \text{s}/\text{m}^{-3}$	$\text{C}/\text{m}^3$	$\text{C}/\text{m}^3$	

$\backslash\text{volumemassdensity}\{\langle\text{magnitude}\rangle\}$

name			
\volumemassdensity			
base	derived	alternate	
$\text{kg} \cdot \text{m}^{-3}$	$\text{kg}/\text{m}^3$	$\text{kg}/\text{m}^3$	

$\backslash\text{wavelength}\{\langle\text{magnitude}\rangle\}$

name			
\wavelength			
base	derived	alternate	
m	m	m	

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`\wavenumber{⟨magnitude⟩}`  
`\wavenumbervector{⟨c1, ..., cn⟩}`  
`\vectorwavenumber{⟨c1, ..., cn⟩}`

**name**

`\wavenumber`

base  
 $\text{m}^{-1}$

derived  
 $/\text{m}$

alternate  
 $/\text{m}$

`\work{⟨magnitude⟩}`

**name**

`\work`

base  
 $\text{kg} \cdot \text{m}^2 \cdot \text{s}^{-2}$

derived  
 $\text{J}$

alternate  
 $\text{J}$

`\youngsmodulus{⟨magnitude⟩}`

**name**

`\youngsmodulus`

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

derived  
 $\text{Pa}$

alternate  
 $\text{N}/\text{m}^2$

### 3.3.4 Defining and Redefining Physical Quantities

N 2021-02-16

N 2021-02-21

`\newsclarquantity{⟨name⟩}{⟨base units⟩}[⟨derived units⟩][⟨alternate units⟩]`  
`\renewsclarquantity{⟨name⟩}{⟨base units⟩}[⟨derived units⟩][⟨alternate units⟩]`

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

N 2021-02-16

N 2021-02-21

`\newvectorquantity{⟨name⟩}{⟨base units⟩}[⟨derived units⟩][⟨alternate units⟩]`  
`\renewvectorquantity{⟨name⟩}{⟨base units⟩}[⟨derived units⟩][⟨alternate units⟩]`

Command to define/redefine a new/existing vector quantity. If the derived or alternate units are omitted, they are defined to be the same as the base units. Do not use both this command and `\newsclarquantity` or `\renewsclarquantity` to define/redefine 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`<sup>P.9</sup> or `physical constant`<sup>P.25</sup> 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

`\alwaysusebaseunits`  
`\alwaysusederivedunits`

U 2021-02-26

## **\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

## **\hereusebaseunits{⟨content⟩}**

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## **\hereusederivedunits{⟨content⟩}**

U 2021-02-26

## **\hereusedalternateunits{⟨content⟩}**

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

<code>\hereusebaseunits{\momentum{5}}</code>	<code>\\</code>	$5 \text{ kg} \cdot \text{m} \cdot \text{s}^{-1}$
<code>\hereusederivedunits{\momentum{5}}</code>	<code>\\</code>	$5 \text{ kg} \cdot \text{m/s}$
<code>\hereusealternateunits{\momentum{5}}</code>	<code>\\</code>	$5 \text{ kg} \cdot \text{m/s}$
<code>\hereusebaseunits{\oofpez}</code>	<code>\\</code>	$9 \times 10^9 \text{ kg} \cdot \text{m}^3 \cdot \text{A}^{-2} \cdot \text{s}^{-4}$
<code>\hereusederivedunits{\oofpez}</code>	<code>\\</code>	$9 \times 10^9 \text{ m/F}$
<code>\hereusealternateunits{\oofpez}</code>		$9 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2$

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**\begin{usebaseunits}** (use base units)  
*⟨environment content⟩*

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**\end{usebaseunits}**  
**\begin{usederivedunits}** (use derived units)  
*⟨environment content⟩*

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**\end{usederivedunits}**  
**\begin{usealternateunits}** (use alternate units)  
*⟨environment content⟩*  
**\end{usealternateunits}**

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

<code>\momentum{5}</code>	<code>\\</code>	
<code>\oofpez</code>	<code>\\</code>	
<code>\begin{usebaseunits}</code>		$5 \text{ kg} \cdot \text{m/s}$
<code>\momentum{5}</code>	<code>\\</code>	$9 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2$
<code>\oofpez</code>	<code>\\</code>	$5 \text{ kg} \cdot \text{m} \cdot \text{s}^{-1}$
<code>\end{usebaseunits}</code>		$9 \times 10^9 \text{ kg} \cdot \text{m}^3 \cdot \text{A}^{-2} \cdot \text{s}^{-4}$
<code>\begin{usederivedunits}</code>		$5 \text{ kg} \cdot \text{m/s}$
<code>\momentum{5}</code>	<code>\\</code>	$9 \times 10^9 \text{ m/F}$
<code>\oofpez</code>	<code>\\</code>	$5 \text{ kg} \cdot \text{m/s}$
<code>\end{usederivedunits}</code>		$9 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2$
<code>\begin{usealternateunits}</code>		$5 \text{ kg} \cdot \text{m/s}$
<code>\momentum{5}</code>	<code>\\</code>	$9 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2$
<code>\oofpez</code>		
<code>\end{usealternateunits}</code>		



## 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.

<code>\oofpez</code>	<code>\</code>	$9 \times 10^9 \text{ N} \cdot \text{m}^2 / \text{C}^2$
<code>\oofpezapproximatevalue</code>	<code>\</code>	$9 \times 10^9$
<code>\oofpezprecisevalue</code>	<code>\</code>	$8.9875517923 \times 10^9$
<code>\oofpezmathsymbol</code>	<code>\</code>	$\frac{1}{4\pi\epsilon_0}$
<code>\oofpezbaseunits</code>	<code>\</code>	$9 \times 10^9 \text{ kg} \cdot \text{m}^3 \cdot \text{A}^{-2} \cdot \text{s}^{-4}$
<code>\oofpezderivedunits</code>	<code>\</code>	$9 \times 10^9 \text{ m/F}$
<code>\oofpezalternateunits</code>	<code>\</code>	$9 \times 10^9 \text{ N} \cdot \text{m}^2 / \text{C}^2$
<code>\oofpezonlybaseunits</code>	<code>\</code>	$\text{kg} \cdot \text{m}^3 \cdot \text{A}^{-2} \cdot \text{s}^{-4}$
<code>\oofpezonlyderivedunits</code>	<code>\</code>	$\text{m/F}$
<code>\oofpezonlyalternateunits</code>	<code>\</code>	$\text{N} \cdot \text{m}^2 / \text{C}^2$

### 3.4.2 Checking Physical Constants

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#### **\checkconstant{<name>}**

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

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`<sup>P.26</sup> and `\biotsavartconstant`<sup>P.26</sup> are defined as semantic aliases for, respectively, `\oofpez`<sup>P.29</sup> and `\mzofp`<sup>P.29</sup>.

#### **\avogadro**

(exact)

##### name

`\avogadro`

base

$N_A$

base

$\text{mol}^{-1}$

approximate

$6 \times 10^{23}$

derived

/mol

precise

$6.02214076 \times 10^{23}$

alternate

/mol

**\biotsavartconstant****name****\biotsavartconstant**

base	approximate	precise
$\frac{\mu_0}{4\pi}$	$10^{-7}$	$10^{-7}$
base	derived	alternate
$\text{kg} \cdot \text{m} \cdot \text{A}^{-2} \cdot \text{s}^{-2}$	H/m	T · m/A

**\bohrradius****name****\bohrradius**

base	approximate	precise
$a_0$	$5.3 \times 10^{-11}$	$5.29177210903 \times 10^{-11}$
base	derived	alternate
m	m	m

**\boltzmann**

(exact)

**name****\boltzmann**

base	approximate	precise
$k_B$	$1.4 \times 10^{-23}$	$1.380649 \times 10^{-23}$
base	derived	alternate
$\text{kg} \cdot \text{m}^2 \cdot \text{s}^{-2} \cdot \text{K}^{-1}$	J/K	J/K

**\coulombconstant****name****\coulombconstant**

base	approximate	precise
$\frac{1}{4\pi\epsilon_0}$	$9 \times 10^9$	$8.9875517923 \times 10^9$
base	derived	alternate
$\text{kg} \cdot \text{m}^3 \cdot \text{A}^{-2} \cdot \text{s}^{-4}$	m/F	N · m <sup>2</sup> /C <sup>2</sup>

**\earthmass****name****\earthmass**

base	approximate	precise
$M_{\text{Earth}}$	$6.0 \times 10^{24}$	$5.9722 \times 10^{24}$
base	derived	alternate
kg	kg	kg

**\earthmoondistance**

**name**

**\earthmoondistance**

base	approximate	precise
$d_{EM}$	$3.8 \times 10^8$	$3.81550 \times 10^8$
base	derived	alternate
m	m	m

**\earthradius**

**name**

**\earthradius**

base	approximate	precise
$R_{Earth}$	$6.4 \times 10^6$	$6.3781 \times 10^6$
base	derived	alternate
m	m	m

**\earthsundistance**

**name**

**\earthsundistance**

base	approximate	precise
$d_{ES}$	$1.5 \times 10^{11}$	$1.496 \times 10^{11}$
base	derived	alternate
m	m	m

**\electroncharge**

**name**

**\electroncharge**

base	approximate	precise
$q_e$	$-1.6 \times 10^{-19}$	$-1.602176634 \times 10^{-19}$
base	derived	alternate
A · s	C	C

**\electronCharge**

**name**

**\electronCharge**

base	approximate	precise
$Q_e$	$-1.6 \times 10^{-19}$	$-1.602176634 \times 10^{-19}$
base	derived	alternate
A · s	C	C

**\electronmass**

### name

#### \electronmass

base	approximate	precise
$m_e$	$9.1 \times 10^{-31}$	$9.1093837015 \times 10^{-31}$
base	derived	alternate
kg	kg	kg

### \elementarycharge (exact)

### name

#### \elementarycharge

base	approximate	precise
e	$1.6 \times 10^{-19}$	$1.602176634 \times 10^{-19}$
base	derived	alternate
A·s	C	C

### \finestructure

### name

#### \finestructure

base	approximate	precise
$\alpha$	$\frac{1}{137}$	$7.2973525693 \times 10^{-3}$
base	derived	alternate

### \hydrogenmass

### name

#### \hydrogenmass

base	approximate	precise
$m_H$	$1.7 \times 10^{-27}$	$1.6737236 \times 10^{-27}$
base	derived	alternate
kg	kg	kg

### \moonearthdistance

### name

#### \moonearthdistance

base	approximate	precise
$d_{ME}$	$3.8 \times 10^8$	$3.81550 \times 10^8$
base	derived	alternate
m	m	m

### \moonmass

# name

## \moonmass

base	approximate	precise
$M_{\text{Moon}}$	$7.3 \times 10^{22}$	$7.342 \times 10^{22}$
base	derived	alternate
kg	kg	kg

## \moonradius

# name

## \moonradius

base	approximate	precise
$R_{\text{Moon}}$	$1.7 \times 10^6$	$1.7371 \times 10^6$
base	derived	alternate
m	m	m

## \mzofp

# name

## \mzofp

base	approximate	precise
$\frac{\mu_0}{4\pi}$	$10^{-7}$	$10^{-7}$
base	derived	alternate
$\text{kg} \cdot \text{m} \cdot \text{A}^{-2} \cdot \text{s}^{-2}$	H/m	T · m/A

## \neutronmass

# name

## \neutronmass

base	approximate	precise
$m_n$	$1.7 \times 10^{-27}$	$1.67492749804 \times 10^{-27}$
base	derived	alternate
kg	kg	kg

## \oofpez

# name

## \oofpez

base	approximate	precise
$\frac{1}{4\pi\epsilon_0}$	$9 \times 10^9$	$8.9875517923 \times 10^9$
base	derived	alternate
$\text{kg} \cdot \text{m}^3 \cdot \text{A}^{-2} \cdot \text{s}^{-4}$	m/F	N · m <sup>2</sup> /C <sup>2</sup>

## \oofpezcs

**name**

**\oofpezcs**

base	approximate	precise
$\frac{1}{4\pi\epsilon_0 c^2}$	$10^{-7}$	$10^{-7}$
base	derived	alternate
$\text{kg} \cdot \text{m} \cdot \text{A}^{-2} \cdot \text{s}^{-2}$	$\text{T} \cdot \text{m}^2$	$\text{N} \cdot \text{s}^2 / \text{C}^2$

**\planck** (exact)

**name**

**\planck**

base	approximate	precise
$h$	$6.6 \times 10^{-34}$	$6.62607015 \times 10^{-34}$
base	derived	alternate
$\text{kg} \cdot \text{m}^2 \cdot \text{s}^{-1}$	$\text{J} \cdot \text{s}$	$\text{J} \cdot \text{s}$

**\planckbar**

**name**

**\planckbar**

base	approximate	precise
$h$	$1.1 \times 10^{-34}$	$1.054571817 \times 10^{-34}$
base	derived	alternate
$\text{kg} \cdot \text{m}^2 \cdot \text{s}^{-1}$	$\text{J} \cdot \text{s}$	$\text{J} \cdot \text{s}$

**\planckc**

**name**

**\planckc**

base	approximate	precise
$hc$	$2.0 \times 10^{-25}$	$1.98644586 \times 10^{-25}$
base	derived	alternate
$\text{kg} \cdot \text{m}^3 \cdot \text{s}^{-2}$	$\text{J} \cdot \text{m}$	$\text{J} \cdot \text{m}$

**\protoncharge**

**name**

**\protoncharge**

base	approximate	precise
$q_p$	$+1.6 \times 10^{-19}$	$+1.602176634 \times 10^{-19}$
base	derived	alternate
$\text{A} \cdot \text{s}$	$\text{C}$	$\text{C}$

**\protonCharge**

name		
\protonCharge		
base	approximate	precise
$Q_p$	$+1.6 \times 10^{-19}$	$+1.602176634 \times 10^{-19}$
base	derived	alternate
$A \cdot s$	C	C

### \protonmass

name		
\protonmass		
base	approximate	precise
$m_p$	$1.7 \times 10^{-27}$	$1.672621898 \times 10^{-27}$
base	derived	alternate
kg	kg	kg

### \rydberg

name		
\rydberg		
base	approximate	precise
$R_\infty$	$1.1 \times 10^7$	$1.0973731568160 \times 10^7$
base	derived	alternate
$m^{-1}$	$m^{-1}$	$m^{-1}$

### \speedoflight (exact)

name		
\speedoflight		
base	approximate	precise
c	$3 \times 10^8$	$2.99792458 \times 10^8$
base	derived	alternate
$m \cdot s^{-1}$	m/s	m/s

### \stefanboltzmann

name		
\stefanboltzmann		
base	approximate	precise
$\sigma$	$5.7 \times 10^{-8}$	$5.670374 \times 10^{-8}$
base	derived	alternate
$kg \cdot s^{-3} \cdot K^{-4}$	$W/m^2 \cdot K^4$	$W/m^2 \cdot K^4$

### \sunearthdistance

### name

#### \sunearthdistance

base	approximate	precise
$d_{SE}$	$1.5 \times 10^{11}$	$1.496 \times 10^{11}$
base	derived	alternate
m	m	m

### \sunradius

### name

#### \sunradius

base	approximate	precise
$R_{Sun}$	$7.0 \times 10^8$	$6.957 \times 10^8$
base	derived	alternate
m	m	m

### \surfacegravfield

### name

#### \surfacegravfield

base	approximate	precise
g	9.8	9.807
base	derived	alternate
$m \cdot s^{-2}$	N/kg	N/kg

### \universalgrav

### name

#### \universalgrav

base	approximate	precise
G	$6.7 \times 10^{-11}$	$6.67430 \times 10^{-11}$
base	derived	alternate
$m^3 \cdot kg^{-1} \cdot s^{-2}$	$N \cdot m^2/kg^2$	$N \cdot m^2/kg^2$

### \vacuumpermeability

### name

#### \vacuumpermeability

base	approximate	precise
$\mu_0$	$4\pi \times 10^{-7}$	$4\pi \times 10^{-7}$
base	derived	alternate
$kg \cdot m \cdot A^{-2} \cdot s^{-2}$	H/m	T · m/A

### \vacuumpermittivity



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

### 3.4.4 Defining and Redefining Physical Constants

`\newphysicalconstant`  $\{\langle name \rangle\}\{\langle symbol \rangle\}\{\langle approximate value \rangle\}\{\langle precise value \rangle\}\{\langle base units \rangle\}$   
 $[\langle derived units \rangle] [\langle alternate units \rangle]$

`\renewphysicalconstant`  $\{\langle name \rangle\}\{\langle symbol \rangle\}\{\langle approximate value \rangle\}\{\langle precise value \rangle\}\{\langle base units \rangle\}$   
 $[\langle derived units \rangle] [\langle alternate units \rangle]$

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.23</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.

`\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`<sup>→P.8</sup> key.

`\hereuseapproximateconstants` $\{\langle content \rangle\}$

`\hereusepreciseconstants` $\{\langle content \rangle\}$

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

<code>\hereuseapproximateconstants{\oofpez} \\\</code>	$9 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2$
<code>\hereusepreciseconstants{\oofpez}</code>	$8.9875517923 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2$

`\begin{useapproximateconstants}` (use approximate constants)  
 $\langle environment content \rangle$

`\end{useapproximateconstants}`

`\begin{usepreciseconstants}` (use precise constants)  
 $\langle environment content \rangle$

`\end{usepreciseconstants}`

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

<pre> \oofpez      \\\ \begin{useapproximateconstants} \oofpez      \\\ \end{useapproximateconstants} \begin{usepreciseconstants} \oofpez      \\\ \end{usepreciseconstants} \oofpez </pre>	$9 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2$ $9 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2$ $8.9875517923 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2$ $9 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2$
---	---

### 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.

<code>\per</code>	
<code>\usk</code>	
<code>\unit{\langle magnitude \rangle}{\langle unit \rangle}</code>	
<code>\emptyunit</code>	
<code>\ampere</code>	
<code>\atomicmassunit</code>	
<code>\candela</code>	
<code>\coulomb</code>	
<code>\degree</code>	
<code>\electronvolt</code>	(not SI but common in introductory physics)
<code>\ev</code>	(alias)
<code>\farad</code>	
<code>\henry</code>	
<code>\hertz</code>	
<code>\joule</code>	
<code>\kelvin</code>	
<code>\kev</code>	(alias)
<code>\kiloelectronvolt</code>	(not SI but common in introductory physics)
<code>\kilogram</code>	
<code>\lightspeed</code>	(not SI but common relativity)
<code>\megaelectronvolt</code>	(not SI but common in introductory physics)
<code>\meter</code>	
<code>\metre</code>	(alias)
<code>\mev</code>	(alias)
<code>\mole</code>	
<code>\newton</code>	
<code>\ohm</code>	
<code>\pascal</code>	
<code>\radian</code>	
<code>\second</code>	
<code>\siemens</code>	
<code>\steradian</code>	
<code>\tesla</code>	

<code>\volt</code>	
<code>\watt</code>	
<code>\weber</code>	
<code>\tothetwo</code>	(postfix)
<code>\tothethree</code>	(postfix)
<code>\tothefour</code>	(postfix)
<code>\inverse</code>	(postfix)
<code>\totheinversetwo</code>	(postfix)
<code>\totheinversethree</code>	(postfix)
<code>\totheinversefour</code>	(postfix)

	/
	.
	3 m/s
	$\square$
<code>\per</code>	A
<code>\usk</code>	u
<code>\unit{3}{\meter\per\second}</code>	cd
<code>\emptyunit</code>	C
<code>\ampere</code>	°
<code>\atomicmassunit</code>	
<code>\candela</code>	eV
<code>\coulomb</code>	F
<code>\degree</code>	H
<code>\electronvolt</code>	Hz
<code>\farad</code>	J
<code>\henry</code>	K
<code>\hertz</code>	keV
<code>\joule</code>	kg
<code>\kelvin</code>	c
<code>\kev</code>	m
<code>\kilogram</code>	m
<code>\lightspeed</code>	MeV
<code>\meter</code>	mol
<code>\metre</code>	N
<code>\mev</code>	$\Omega$
<code>\mole</code>	Pa
<code>\newton</code>	rad
<code>\ohm</code>	s
<code>\pascal</code>	S
<code>\radian</code>	sr
<code>\second</code>	T
<code>\siemens</code>	V
<code>\steradian</code>	W
<code>\tesla</code>	Wb
<code>\volt</code>	$\square^2$
<code>\watt</code>	$\square^3$
<code>\weber</code>	$\square^4$
<code>\emptyunit\tothetwo</code>	$\square^{-1}$
<code>\emptyunit\tothethree</code>	$\square^{-2}$
<code>\emptyunit\tothefour</code>	$\square^{-3}$
<code>\emptyunit\inverse</code>	$\square^{-4}$
<code>\emptyunit\totheinversetwo</code>	
<code>\emptyunit\totheinversethree</code>	
<code>\emptyunit\totheinversefour</code>	

`\tento{<number>}`  
`\timestento{<number>}`  
`\xtento{<number>}`

Commands for powers of ten and scientific notation.

```

\(\ \tento{-4} \) \\\
\(\ 3\timestento{8} \) \\\
\(\ 3\xtento{8} \)

```

```

10^{-4}
3 \times 10^8
3 \times 10^8

```

**\mivector** $[\langle \textit{delimiter} \rangle]\{ \langle c_1, \dots, c_n \rangle \}[\langle \textit{units} \rangle]$

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

```

\mivector{p_0,p_1,p_2,p_3} \\\
\mivector{\gamma m v_x,\gamma m v_y,\gamma m v_z} \\\
\mivector{\frac{Q_1Q_2}{x^2},0,0} \\\
\mivector{-1,0,0} \\\
\mivector{-1,0,0}[\velocityonlyderivedunits] \\\
\mivector{-1,0,0}[\meter\per\second] \\\
\velocity{\mivector{-1,0,0}}

```

```

\langle p_0,p_1,p_2,p_3 \rangle
\langle \gamma m v_x,\gamma m v_y,\gamma m v_z \rangle
\langle \frac{Q_1Q_2}{x^2},0,0 \rangle
\langle -1,0,0 \rangle
\langle -1,0,0 \rangle \text{ m/s}
\langle -1,0,0 \rangle \text{ m/s}
\langle -1,0,0 \rangle \text{ m/s}

```

### 3.6 mandi Source Code

Define 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{2021-05-28}
3 \NeedsTeXFormat{LaTeX2e}[1999/12/01]
4 \providecommand\DeclareRelease[3]{}
5 \providecommand\DeclareCurrentRelease[2]{}
6 \DeclareRelease{v3.0.0m}{2021-05-28}{mandi.sty}
7 \DeclareCurrentRelease{v\mandi@Version}{\mandi@Date}
8 \ProvidesPackage{mandi}
9 [\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{pgfplots}      % 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}{}
24 {\renewcommand*\mandi@selectunits{\mandi@selectbaseunits}}%
25 \NewDocumentCommand{\alwaysusederivedunits}{}
26 {\renewcommand*\mandi@selectunits{\mandi@selectderivedunits}}%
27 \NewDocumentCommand{\alwaysusealternateunits}{}
28 {\renewcommand*\mandi@selectunits{\mandi@selectalternateunits}}%
29 \NewDocumentCommand{\alwaysuseapproximateconstants}{}
30 {\renewcommand*\mandi@selectprecision{\mandi@selectapproximate}}%
31 \NewDocumentCommand{\alwaysusepreciseconstants}{}
32 {\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}%
36 \NewDocumentCommand{\hereuseapproximateconstants}{ m }{\begingroup\alwaysuseapproximateconstants#1\endgroup}%
37 \NewDocumentCommand{\hereusepreciseconstants}{ m }{\begingroup\alwaysusepreciseconstants#1\endgroup}%

```

Document level environments.

```
38 \NewDocumentEnvironment{usebaseunits}{}{\alwaysusebaseunits}{}%
39 \NewDocumentEnvironment{usederivedunits}{}{\alwaysusederivedunits}{}%
```

```

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→P.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{%
45   /mandi/options/.cd,
46   initial@setup/.style={%
47     /mandi/options/buffered@units/.initial=alternate,%
48   },%
49   initial@setup,%
50   preciseconstants/.is if=usingpreciseconstants,%
51   units/.is choice,%
52   units/.default=derived,%
53   units/alternate/.style={/mandi/options/buffered@units=alternate},%
54   units/base/.style={/mandi/options/buffered@units=base},%
55   units/derived/.style={/mandi/options/buffered@units=derived},%
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}{%
63   \csname alwaysuse\pgfkeysvalueof{/mandi/options/buffered@units}units\endcsname%
64   \typeout{mandi: You will get \pgfkeysvalueof{/mandi/options/buffered@units}\space units.}%
65   \ifusingpreciseconstants
66     \alwaysusepreciseconstants
67     \typeout{mandi: You will get precise constants.}%
68   \else
69     \alwaysuseapproximateconstants
70     \typeout{mandi: You will get approximate constants.}%
71   \fi
72   \typeout{}%
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 }{%
76   \IfValueT{#1}{%
77     \pgfqkeys{/mandi/options}{#1}
78     \typeout{}%
79     \typeout{mandi: mandisetup options...}
80     \mandi@do@setup
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}{-}{\ensuremath{/}}
84 \NewDocumentCommand{\usk}{-}{\ensuremath{\,\cdot\,}}
85 \NewDocumentCommand{\unit}{ m m }{\ensuremath{\{#1\};\{#2\}}}
86 \NewDocumentCommand{\ampere}{-}{\ensuremath{\symup{A}}}
87 \NewDocumentCommand{\atomicmassunit}{-}{\ensuremath{\symup{u}}}
88 \NewDocumentCommand{\candela}{-}{\ensuremath{\symup{cd}}}
89 \NewDocumentCommand{\coulomb}{-}{\ensuremath{\symup{C}}}
90 \NewDocumentCommand{\degree}{-}{\ensuremath{^\circ}}
91 \NewDocumentCommand{\electronvolt}{-}{\ensuremath{\symup{eV}}}
92 \NewDocumentCommand{\ev}{-}{\electronvolt}
93 \NewDocumentCommand{\farad}{-}{\ensuremath{\symup{F}}}
94 \NewDocumentCommand{\henry}{-}{\ensuremath{\symup{H}}}
95 \NewDocumentCommand{\hertz}{-}{\ensuremath{\symup{Hz}}}
96 \NewDocumentCommand{\joule}{-}{\ensuremath{\symup{J}}}
97 \NewDocumentCommand{\kelvin}{-}{\ensuremath{\symup{K}}}
98 \NewDocumentCommand{\kev}{-}{\kilolectronvolt}
99 \NewDocumentCommand{\kilolectronvolt}{-}{\ensuremath{\symup{keV}}}
100 \NewDocumentCommand{\kilogram}{-}{\ensuremath{\symup{kg}}}
101 \NewDocumentCommand{\lightspeed}{-}{\ensuremath{\symup{c}}}
102 \NewDocumentCommand{\megaelectronvolt}{-}{\ensuremath{\symup{MeV}}}
103 \NewDocumentCommand{\meter}{-}{\ensuremath{\symup{m}}}
104 \NewDocumentCommand{\metre}{-}{\meter}
105 \NewDocumentCommand{\mev}{-}{\megaelectronvolt}
106 \NewDocumentCommand{\mole}{-}{\ensuremath{\symup{mol}}}
107 \NewDocumentCommand{\newton}{-}{\ensuremath{\symup{N}}}
108 \NewDocumentCommand{\ohm}{-}{\ensuremath{\symup{\Omega}}}
109 \NewDocumentCommand{\pascal}{-}{\ensuremath{\symup{Pa}}}
110 \NewDocumentCommand{\radian}{-}{\ensuremath{\symup{rad}}}
111 \NewDocumentCommand{\second}{-}{\ensuremath{\symup{s}}}
112 \NewDocumentCommand{\siemens}{-}{\ensuremath{\symup{S}}}
113 \NewDocumentCommand{\steradian}{-}{\ensuremath{\symup{sr}}}
114 \NewDocumentCommand{\tesla}{-}{\ensuremath{\symup{T}}}
115 \NewDocumentCommand{\volt}{-}{\ensuremath{\symup{V}}}
116 \NewDocumentCommand{\watt}{-}{\ensuremath{\symup{W}}}
117 \NewDocumentCommand{\weber}{-}{\ensuremath{\symup{Wb}}}
118 \NewDocumentCommand{\tothetwo}{-}{\ensuremath{\sim^2}} % postfix 2
119 \NewDocumentCommand{\tothethree}{-}{\ensuremath{\sim^3}} % postfix 3
120 \NewDocumentCommand{\tothefour}{-}{\ensuremath{\sim^4}} % postfix 4
121 \NewDocumentCommand{\inverse}{-}{\ensuremath{\sim^{-1}}} % postfix -1
122 \NewDocumentCommand{\totheinversetwo}{-}{\ensuremath{\sim^{-2}}} % postfix -2
123 \NewDocumentCommand{\totheinversethree}{-}{\ensuremath{\sim^{-3}}} % postfix -3
124 \NewDocumentCommand{\totheinversefour}{-}{\ensuremath{\sim^{-4}}} % postfix -4
125 \NewDocumentCommand{\emptyunit}{-}{\ensuremath{\mathrm{mdlgwhtsquare}}}
126 \NewDocumentCommand{\tento}{ m }{\ensuremath{10^{#1}}}
127 \NewDocumentCommand{\timestento}{ m }{\ensuremath{\,\times\,};\tento{#1}}
128 \NewDocumentCommand{\xtento}{ m }{\ensuremath{\,\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 L<sup>A</sup>T<sub>E</sub>X3 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 \NewDocumentCommand{\newscalarquantity}{ m m O{#2} O{#2} }{%
130   \expandafter\newcommand\csname #1\endcsname[1]{##1\,\mandi@selectunits{#2}{#3}{#4}}%
131   \expandafter\newcommand\csname #1value\endcsname[1]{##1}%
132   \expandafter\newcommand\csname #1baseunits\endcsname[1]{##1\,\mandi@selectbaseunits{#2}{#3}{#4}}%
133   \expandafter\newcommand\csname #1derivedunits\endcsname[1]{##1\,\mandi@selectderivedunits{#2}{#3}{#4}}%
134   \expandafter\newcommand\csname #1alternateunits\endcsname[1]{##1\,\mandi@selectalternateunits{#2}{#3}{#4}}%

```



```

135 \expandafter\newcommand\csname #1onlybaseunits\endcsname{\mandi@selectbaseunits{#2}{#3}{#4}}%
136 \expandafter\newcommand\csname #1onlyderivedunits\endcsname{\mandi@selectderivedunits{#2}{#3}{#4}}%
137 \expandafter\newcommand\csname #1onlyalternateunits\endcsname{\mandi@selectalternateunits{#2}{#3}{#4}}%
138 }%

```

Redefining an existing scalar quantity.

```

139 \NewDocumentCommand{\renewscalarquantity}{ m m O{#2} O{#2} }{%
140 \expandafter\renewcommand\csname #1\endcsname[1]{##1\,\mandi@selectunits{#2}{#3}{#4}}%
141 \expandafter\renewcommand\csname #1value\endcsname[1]{##1}%
142 \expandafter\renewcommand\csname #1baseunits\endcsname[1]{##1\,\mandi@selectbaseunits{#2}{#3}{#4}}%
143 \expandafter\renewcommand\csname #1derivedunits\endcsname[1]{##1\,\mandi@selectderivedunits{#2}{#3}{#4}}%
144 \expandafter\renewcommand\csname #1alternateunits\endcsname[1]{##1\,\mandi@selectalternateunits{#2}{#3}{#4}}%
145 \expandafter\renewcommand\csname #1onlybaseunits\endcsname{\mandi@selectbaseunits{#2}{#3}{#4}}%
146 \expandafter\renewcommand\csname #1onlyderivedunits\endcsname{\mandi@selectderivedunits{#2}{#3}{#4}}%
147 \expandafter\renewcommand\csname #1onlyalternateunits\endcsname{\mandi@selectalternateunits{#2}{#3}{#4}}%
148 }%

```

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

```

149 \NewDocumentCommand{\newvectorquantity}{ m m O{#2} O{#2} }{%
150 \newscalarquantity{#1}{#2}[#3][#4]
151 \expandafter\newcommand\csname vector#1\endcsname[1]{\expandafter\csname #1\endcsname{\mivector{##1}}}%
152 \expandafter\newcommand\csname #1vector\endcsname[1]{\expandafter\csname #1\endcsname{\mivector{##1}}}%
153 }%

```

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

```

154 \NewDocumentCommand{\renewvectorquantity}{ m m O{#2} O{#2} }{%
155 \renewscalarquantity{#1}{#2}[#3][#4]
156 \expandafter\renewcommand\csname vector#1\endcsname[1]{\expandafter\csname #1\endcsname{\mivector{##1}}}%
157 \expandafter\renewcommand\csname #1vector\endcsname[1]{\expandafter\csname #1\endcsname{\mivector{##1}}}%
158 }%

```

Defining a new physical constant.

```

159 \NewDocumentCommand{\newphysicalconstant}{ m m m m m O{#5} O{#5} }{%
160 \expandafter\newcommand\csname #1\endcsname
161 {\mandi@selectprecision{#3}{#4}\,\mandi@selectunits{#5}{#6}{#7}}%
162 \expandafter\newcommand\csname #1mathsymbol\endcsname{\ensuremath{#2}}%
163 \expandafter\newcommand\csname #1approximatevalue\endcsname{\ensuremath{#3}}%
164 \expandafter\newcommand\csname #1precisevalue\endcsname{\ensuremath{#4}}%
165 \expandafter\newcommand\csname #1baseunits\endcsname
166 {\mandi@selectprecision{#3}{#4}\,\mandi@selectbaseunits{#5}{#6}{#7}}%
167 \expandafter\newcommand\csname #1derivedunits\endcsname
168 {\mandi@selectprecision{#3}{#4}\,\mandi@selectderivedunits{#5}{#6}{#7}}%
169 \expandafter\newcommand\csname #1alternateunits\endcsname
170 {\mandi@selectprecision{#3}{#4}\,\mandi@selectalternateunits{#5}{#6}{#7}}%
171 \expandafter\newcommand\csname #1onlybaseunits\endcsname
172 {\mandi@selectbaseunits{#5}{#6}{#7}}%
173 \expandafter\newcommand\csname #1onlyderivedunits\endcsname
174 {\mandi@selectderivedunits{#5}{#6}{#7}}%
175 \expandafter\newcommand\csname #1onlyalternateunits\endcsname
176 {\mandi@selectalternateunits{#5}{#6}{#7}}%
177 }%

```

Redefining an existing physical constant.

```

178 \NewDocumentCommand{\renewphysicalconstant}{ m m m m m O{#5} O{#5} }{%
179 \expandafter\renewcommand\csname #1\endcsname
180 {\mandi@selectprecision{#3}{#4}\,\mandi@selectunits{#5}{#6}{#7}}%
181 \expandafter\renewcommand\csname #1mathsymbol\endcsname{\ensuremath{#2}}%
182 \expandafter\renewcommand\csname #1approximatevalue\endcsname{\ensuremath{#3}}%
183 \expandafter\renewcommand\csname #1precisevalue\endcsname{\ensuremath{#4}}%

```

```

184 \expandafter\renewcommand\csname #1baseunits\endcsname
185   {\mandi@selectprecision{#3}{#4}\,\mandi@selectbaseunits{#5}{#6}{#7}}%
186 \expandafter\renewcommand\csname #1derivedunits\endcsname
187   {\mandi@selectprecision{#3}{#4}\,\mandi@selectderivedunits{#5}{#6}{#7}}%
188 \expandafter\renewcommand\csname #1alternateunits\endcsname
189   {\mandi@selectprecision{#3}{#4}\,\mandi@selectalternateunits{#5}{#6}{#7}}%
190 \expandafter\renewcommand\csname #1onlybaseunits\endcsname
191   {\mandi@selectbaseunits{#5}{#6}{#7}}%
192 \expandafter\renewcommand\csname #1onlyderivedunits\endcsname
193   {\mandi@selectderivedunits{#5}{#6}{#7}}%
194 \expandafter\renewcommand\csname #1onlyalternateunits\endcsname
195   {\mandi@selectalternateunits{#5}{#6}{#7}}%
196 }%

```

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.

```

197 \newvectorquantity{acceleration}%
198   {\meter\usk\second\totheinversetwo}%
199   [\newton\per\kilogram]%
200   [\meter\per\second\tothetwo]%
201 \newscalarquantity{amount}%
202   {\mole}%
203 \newvectorquantity{angularacceleration}%
204   {\radian\usk\second\totheinversetwo}%
205   [\radian\per\second\tothetwo]%
206   [\radian\per\second\tothetwo]%
207 \newscalarquantity{angularfrequency}%
208   {\radian\usk\second\inverse}%
209   [\radian\per\second]%
210   [\radian\per\second]%
211 %\ifmandi@rotradians
212 % \newphysicalquantity{angularimpulse}%
213 %   {\meter\tothetwo\usk\kilogram\usk\second\inverse\usk\radian\inverse}%
214 %   [\joule\usk\second\per\radian]%
215 %   [\newton\usk\meter\usk\second\per\radian]%
216 % \newphysicalquantity{angularmomentum}%
217 %   {\meter\tothetwo\usk\kilogram\usk\second\inverse\usk\radian\inverse}%
218 %   [\kilogram\usk\meter\tothetwo\per(\second\usk\radian)]%
219 %   [\newton\usk\meter\usk\second\per\radian]%
220 %\else
221 % \newvectorquantity{angularimpulse}%
222 %   {\kilogram\usk\meter\tothetwo\usk\second\inverse}%
223 %   [\kilogram\usk\meter\tothetwo\per\second]% % also \joule\usk\second
224 %   [\kilogram\usk\meter\tothetwo\per\second]% % also \newton\usk\meter\usk\second
225 % \newvectorquantity{angularmomentum}%
226 %   {\kilogram\usk\meter\tothetwo\usk\second\inverse}%
227 %   [\kilogram\usk\meter\tothetwo\per\second]% % also \joule\usk\second
228 %   [\kilogram\usk\meter\tothetwo\per\second]% % also \newton\usk\meter\usk\second
229 %\fi
230 \newvectorquantity{angularvelocity}%
231   {\radian\usk\second\inverse}%
232   [\radian\per\second]%
233   [\radian\per\second]%
234 \newscalarquantity{area}%
235   {\meter\tothetwo}%
236 \newscalarquantity{areachargedensity}%
237   {\ampere\usk\second\usk\meter\totheinversetwo}%
238   [\coulomb\per\meter\tothetwo]%

```

```

239  [\coulomb\per\meter\tothetwo]%
240 \newscalarquantity{areamassdensity}%
241  {\kilogram\usk\meter\totheinversetwo}%
242  [\kilogram\per\meter\tothetwo]%
243  [\kilogram\per\meter\tothetwo]%
244 \newscalarquantity{capacitance}%
245  {\ampere\tothetwo\usk\second\tothefour\usk\kilogram\inverse\usk\meter\totheinversetwo}%
246  [\farad]%
247  [\coulomb\per\volt]% % also \coulomb\tothetwo\per\newton\usk\meter, \second\per\ohm
248 \newscalarquantity{charge}%
249  {\ampere\usk\second}%
250  [\coulomb]%
251  [\coulomb]% % also \farad\usk\volt
252 \newvectorquantity{cmagneticfield}%
253  {\kilogram\usk\meter\usk\ampere\inverse\usk\second\totheinversethree}%
254  [\newton\per\coulomb]% % also \volt\per\meter
255  [\newton\per\coulomb]%
256 \newscalarquantity{conductance}%
257  {\ampere\tothetwo\usk\second\tothethree\usk\kilogram\inverse\usk\meter\totheinversetwo}%
258  [\siemens]%
259  [\ampere\per\volt]%
260 \newscalarquantity{conductivity}%
261  {\ampere\tothetwo\usk\second\tothethree\usk\kilogram\inverse\usk\meter\totheinversethree}%
262  [\siemens\per\meter]%
263  [\ampere\per\volt\usk\meter]%
264 \newscalarquantity{conventionalcurrent}%
265  {\ampere}%
266  [\coulomb\per\second]%
267  [\ampere]%
268 \newscalarquantity{current}%
269  {\ampere}%
270 \newscalarquantity{currentdensity}%
271  {\ampere\usk\meter\totheinversetwo}%
272  [\coulomb\per\second\usk\meter\tothetwo]%
273  [\ampere\per\meter\tothetwo]%
274 \newscalarquantity{dielectricconstant}%
275  {}%
276 \newvectorquantity{displacement}%
277  {\meter}%
278 \newscalarquantity{duration}%
279  {\second}%
280 \newvectorquantity{electricdipolemoment}%
281  {\ampere\usk\second\usk\meter}%
282  [\coulomb\usk\meter]%
283  [\coulomb\usk\meter]%
284 \newvectorquantity{electricfield}%
285  {\kilogram\usk\meter\usk\ampere\inverse\usk\second\totheinversethree}%
286  [\volt\per\meter]%
287  [\newton\per\coulomb]%
288 \newscalarquantity{electricflux}%
289  {\kilogram\usk\meter\tothethree\usk\ampere\inverse\usk\second\totheinversethree}%
290  [\volt\usk\meter]%
291  [\newton\usk\meter\tothetwo\per\coulomb]%
292 \newscalarquantity{electricpotential}%
293  {\kilogram\usk\meter\tothetwo\usk\ampere\inverse\usk\second\totheinversethree}%
294  [\volt]% % also \joule\per\coulomb
295  [\volt]%
296 \newscalarquantity{electricpotentialdifference}%
297  {\kilogram\usk\meter\tothetwo\usk\ampere\inverse\usk\second\totheinversethree}%

```

```

298 [\volt]% % also \joule\per\coulomb
299 [\volt]%
300 \newscalarquantity{electroncurrent}%
301 {\second\inverse}%
302 [\ensuremath{\mathrm{e}}\per\second]%
303 [\ensuremath{\mathrm{e}}\per\second]%
304 \newscalarquantity{emf}%
305 {\kilogram\usk\meter\tothetwo\usk\ampere\inverse\usk\second\totheinversethree}%
306 [\volt]% % also \joule\per\coulomb
307 [\volt]%
308 \newscalarquantity{energy}%
309 {\kilogram\usk\meter\tothetwo\usk\second\totheinversetwo}%
310 [\joule]% % also \newton\usk\meter
311 [\joule]%
312 \newscalarquantity{energyinev}%
313 {\electronvolt}%
314 \newscalarquantity{energyinkev}%
315 {\kilolectronvolt}%
316 \newscalarquantity{energyinmev}%
317 {\megaelectronvolt}%
318 \newscalarquantity{energydensity}%
319 {\kilogram\usk\meter\inverse\usk\second\totheinversetwo}%
320 [\joule\per\meter\tothethree]%
321 [\joule\per\meter\tothethree]%
322 \newscalarquantity{energyflux}%
323 {\kilogram\usk\second\totheinversethree}%
324 [\watt\per\meter\tothetwo]%
325 [\watt\per\meter\tothetwo]%
326 \newscalarquantity{entropy}%
327 {\kilogram\usk\meter\tothetwo\usk\second\totheinversetwo\usk\kelvin\inverse}%
328 [\joule\per\kelvin]%
329 [\joule\per\kelvin]%
330 \newvectorquantity{force}%
331 {\kilogram\usk\meter\usk\second\totheinversetwo}%
332 [\newton]%
333 [\newton]% % also \kilogram\usk\meter\per\second\tothetwo
334 \newscalarquantity{frequency}%
335 {\second\inverse}%
336 [\hertz]%
337 [\hertz]%
338 \newvectorquantity{gravitationalfield}%
339 {\meter\usk\second\totheinversetwo}%
340 [\newton\per\kilogram]%
341 [\newton\per\kilogram]%
342 \newscalarquantity{gravitationalpotential}%
343 {\meter\tothetwo\usk\second\totheinversetwo}%
344 [\joule\per\kilogram]%
345 [\joule\per\kilogram]%
346 \newscalarquantity{gravitationalpotentialdifference}%
347 {\meter\tothetwo\usk\second\totheinversetwo}%
348 [\joule\per\kilogram]%
349 [\joule\per\kilogram]%
350 \newvectorquantity{impulse}%
351 {\kilogram\usk\meter\usk\second\inverse}%
352 [\newton\usk\second]%
353 [\newton\usk\second]%
354 \newscalarquantity{indexofrefraction}%
355 {}%
356 \newscalarquantity{inductance}%

```

357  $\{\text{kg}\cdot\text{m}\cdot\text{s}^{-2}\cdot\text{A}^{-1}\}$   
 358  $[\text{H}]$   
 359  $[\text{V}\cdot\text{s}\cdot\text{A}^{-1}]$  % also  $\text{m}^2\cdot\text{kg}\cdot\text{s}^{-2}\cdot\text{A}^{-2}$ ,  $\text{Wb}\cdot\text{A}^{-1}$   
 360  $\text{new\_scalar\_quantity}\{\text{linear\_chargedensity}\}$   
 361  $\{\text{A}\cdot\text{s}\cdot\text{m}^{-1}\}$   
 362  $[\text{C}\cdot\text{m}^{-1}]$   
 363  $[\text{C}\cdot\text{m}^{-1}]$   
 364  $\text{new\_scalar\_quantity}\{\text{linear\_massdensity}\}$   
 365  $\{\text{kg}\cdot\text{m}^{-1}\}$   
 366  $[\text{kg}\cdot\text{m}^{-1}]$   
 367  $[\text{kg}\cdot\text{m}^{-1}]$   
 368  $\text{new\_scalar\_quantity}\{\text{luminousintensity}\}$   
 369  $[\text{cd}]$   
 370  $\text{new\_scalar\_quantity}\{\text{magneticcharge}\}$   
 371  $\{\text{A}\cdot\text{m}\}$  % There is another convention. Be careful!  
 372  $\text{new\_vector\_quantity}\{\text{magneticdipolemoment}\}$   
 373  $\{\text{A}\cdot\text{m}^2\}$   
 374  $[\text{A}\cdot\text{m}^2]$   
 375  $[\text{J}\cdot\text{T}^{-1}]$   
 376  $\text{new\_vector\_quantity}\{\text{magneticfield}\}$   
 377  $\{\text{kg}\cdot\text{A}\cdot\text{s}^{-2}\cdot\text{m}^{-1}\}$   
 378  $[\text{N}\cdot\text{A}^{-1}\cdot\text{m}^{-1}]$  % also  $\text{Wb}\cdot\text{m}^{-2}$   
 379  $[\text{T}]$   
 380  $\text{new\_scalar\_quantity}\{\text{magneticflux}\}$   
 381  $\{\text{kg}\cdot\text{A}\cdot\text{s}^{-2}\cdot\text{m}^{-1}\}$   
 382  $[\text{T}\cdot\text{m}^2]$   
 383  $[\text{V}\cdot\text{s}]$  % also  $\text{Wb}$  and  $\text{J}\cdot\text{A}^{-1}$   
 384  $\text{new\_scalar\_quantity}\{\text{mass}\}$   
 385  $\{\text{kg}\}$   
 386  $\text{new\_scalar\_quantity}\{\text{mobility}\}$   
 387  $\{\text{kg}\cdot\text{A}\cdot\text{s}^{-2}\cdot\text{m}^{-1}\cdot\text{V}^{-1}\}$   
 388  $[\text{m}^2\cdot\text{V}^{-1}\cdot\text{s}\cdot\text{A}^{-1}]$   
 389  $[\text{C}\cdot\text{m}^2\cdot\text{N}^{-1}\cdot\text{s}^{-1}]$   
 390  $\text{new\_scalar\_quantity}\{\text{momentofinertia}\}$   
 391  $\{\text{kg}\cdot\text{m}^2\}$   
 392  $[\text{J}\cdot\text{s}^2\cdot\text{m}^{-2}]$   
 393  $[\text{kg}\cdot\text{m}^2]$   
 394  $\text{new\_vector\_quantity}\{\text{momentum}\}$   
 395  $\{\text{kg}\cdot\text{m}\cdot\text{s}^{-1}\}$   
 396  $[\text{kg}\cdot\text{m}\cdot\text{s}^{-1}]$   
 397  $[\text{kg}\cdot\text{m}\cdot\text{s}^{-1}]$   
 398  $\text{new\_vector\_quantity}\{\text{momentumflux}\}$   
 399  $\{\text{kg}\cdot\text{m}\cdot\text{s}^{-2}\cdot\text{m}^{-1}\}$   
 400  $[\text{N}\cdot\text{m}^{-1}]$   
 401  $[\text{N}\cdot\text{m}^{-1}]$   
 402  $\text{new\_scalar\_quantity}\{\text{numberdensity}\}$   
 403  $\{\text{m}^{-3}\}$   
 404  $[\text{m}^{-3}]$   
 405  $[\text{m}^{-3}]$   
 406  $\text{new\_scalar\_quantity}\{\text{permeability}\}$   
 407  $\{\text{kg}\cdot\text{A}^2\cdot\text{s}^{-2}\cdot\text{m}^{-1}\}$   
 408  $[\text{H}\cdot\text{m}^{-1}]$   
 409  $[\text{T}\cdot\text{m}\cdot\text{A}^{-1}]$   
 410  $\text{new\_scalar\_quantity}\{\text{permittivity}\}$   
 411  $\{\text{A}^2\cdot\text{s}^2\cdot\text{m}^{-1}\cdot\text{kg}^{-1}\}$   
 412  $[\text{F}\cdot\text{m}^{-1}]$   
 413  $[\text{C}^2\cdot\text{m}^{-1}\cdot\text{N}^{-1}]$   
 414  $\text{new\_scalar\_quantity}\{\text{planeangle}\}$   
 415  $\{\text{m}^{-1}\}$

```

416 [\radian]%
417 [\radian]%
418 \newscalarquantity{polarizability}%
419 {\ampere\tothetwo\usk\second\tothefour\usk\kilogram\inverse}%
420 [\coulomb\usk\meter\tothetwo\per\volt]%
421 [\coulomb\tothetwo\usk\meter\per\newton]%
422 \newscalarquantity{power}%
423 {\kilogram\usk\meter\tothetwo\usk\second\totheinversethree}%
424 [\watt]%
425 [\joule\per\second]%
426 \newvectorquantity{poynting}%
427 {\kilogram\usk\second\totheinversethree}%
428 [\watt\per\meter\tothetwo]%
429 [\watt\per\meter\tothetwo]%
430 \newscalarquantity{pressure}%
431 {\kilogram\usk\meter\inverse\usk\second\totheinversetwo}%
432 [\pascal]%
433 [\newton\per\meter\tothetwo]%
434 \newscalarquantity{relativepermeability}%
435 {}%
436 \newscalarquantity{relativepermittivity}%
437 {}%
438 \newscalarquantity{resistance}%
439 {\kilogram\usk\meter\tothetwo\usk\ampere\totheinversetwo\usk\second\totheinversethree}%
440 [\ohm]% % also \volt\per\ampere
441 [\ohm]%
442 \newscalarquantity{resistivity}%
443 {\kilogram\usk\meter\tothethree\usk\ampere\totheinversetwo\usk\second\totheinversethree}%
444 [\ohm\usk\meter]%
445 [\volt\usk\meter\per\ampere]%
446 \newscalarquantity{solidangle}%
447 {\meter\tothetwo\usk\meter\totheinversetwo}%
448 [\steradian]%
449 [\steradian]%
450 \newscalarquantity{specificheatcapacity}%
451 {\meter\tothetwo\usk\second\totheinversetwo\usk\kelvin\inverse}%
452 [\joule\per\kelvin\usk\kilogram]%
453 [\joule\per\kelvin\usk\kilogram]
454 \newscalarquantity{springstiffness}%
455 {\kilogram\usk\second\totheinversetwo}%
456 [\newton\per\meter]%
457 [\newton\per\meter]%
458 \newscalarquantity{springstretch}% % This is really just a displacement.
459 {\meter}%
460 \newscalarquantity{stress}%
461 {\kilogram\usk\meter\inverse\usk\second\totheinversetwo}%
462 [\pascal]%
463 [\newton\per\meter\tothetwo]%
464 \newscalarquantity{strain}%
465 {}%
466 \newscalarquantity{temperature}%
467 {\kelvin}%
468 %\ifmandi@rotradians
469 % \newphysicalquantity{torque}%
470 % {\kilogram\usk\meter\tothetwo\usk\second\totheinversetwo\usk\radian\inverse}%
471 % [\newton\usk\meter\per\radian]%
472 % [\newton\usk\meter\per\radian]%
473 %\else
474 \newvectorquantity{torque}%

```

```

475     {\kilogram\usk\meter\tothetwo\usk\second\totheinversetwo}%
476     [\newton\usk\meter]%
477     [\newton\usk\meter]%
478 %\fi
479 \newvectorquantity{velocity}%
480     {\meter\usk\second\inverse}%
481     [\meter\per\second]%
482     [\meter\per\second]%
483 \newvectorquantity{velocityc}%
484     {\lightspeed}%
485     [\lightspeed]%
486     [\lightspeed]%
487 \newscalarquantity{volume}%
488     {\meter\tothethree}%
489 \newscalarquantity{volumechargedensity}%
490     {\ampere\usk\second\per\meter\totheinversethree}%
491     [\coulomb\per\meter\tothethree]%
492     [\coulomb\per\meter\tothethree]%
493 \newscalarquantity{volumemassdensity}%
494     {\kilogram\usk\meter\totheinversethree}%
495     [\kilogram\per\meter\tothethree]%
496     [\kilogram\per\meter\tothethree]%
497 \newscalarquantity{wavelength}% % This is really just a displacement.
498     {\meter}%
499 \newvectorquantity{wavenumber}%
500     {\meter\inverse}%
501     [\per\meter]%
502     [\per\meter]%
503 \newscalarquantity{work}%
504     {\kilogram\usk\meter\tothetwo\usk\second\totheinversetwo}%
505     [\joule]% % also \newton\usk\meter but discouraged
506     [\joule]%
507 \newscalarquantity{youngsmodulus}% % This is really just a stress.
508     {\kilogram\usk\meter\inverse\usk\second\totheinversetwo}%
509     [\pascal]%
510     [\newton\per\meter\tothetwo]%

```

Define physical constants for introductory physics, again alphabetically for convenience.

```

511 \newphysicalconstant{avogadro}%
512     {\symup{N_A}}%
513     {6\timestento{23}}{6.02214076\timestento{23}}% % exact 2019 value
514     {\mole\inverse}%
515     [\per\mole]%
516     [\per\mole]%
517 \newphysicalconstant{biotsavartconstant}% % alias for \mzofp
518     {\symup{\frac{\mu_o}{4\pi}}}%
519     {\tento{-7}}{\tento{-7}}%
520     {\kilogram\usk\meter\usk\ampere\totheinversetwo\usk\second\totheinversetwo}%
521     [\henry\per\meter]%
522     [\tesla\usk\meter\per\ampere]%
523 \newphysicalconstant{bohrradius}%
524     {\symup{a_o}}%
525     {5.3\timestento{-11}}{5.29177210903\timestento{-11}}%
526     {\meter}%
527 \newphysicalconstant{boltzmann}%
528     {\symup{k_B}}%
529     {1.4\timestento{-23}}{1.380649\timestento{-23}}% % exact 2019 value
530     {\kilogram\usk\meter\tothetwo\usk\second\totheinversetwo\usk\kelvin\inverse}%
531     [\joule\per\kelvin]%

```

```

532 [\joule\per\kelvin]%
533 \newphysicalconstant{coulombconstant}% % alias for \oofpez
534 {\symup{\frac{1}{4\pi\epsilon_0}}}%
535 {9\timestento{9}}{8.9875517923\timestento{9}}%
536 {\kilogram\usk\meter\tothethree\usk\ampere\totheinversetwo\usk\second\totheinversefour}%
537 [\meter\per\farad]%
538 [\newton\usk\meter\tothetwo\per\coulomb\tothetwo]%
539 \newphysicalconstant{earthmass}%
540 {\symup{M_{Earth}}}%
541 {6.0\timestento{24}}{5.9722\timestento{24}}%
542 {\kilogram}%
543 \newphysicalconstant{earthmoondistance}%
544 {\symup{d_{EM}}}%
545 {3.8\timestento{8}}{3.81550\timestento{8}}%
546 {\meter}%
547 \newphysicalconstant{earthradius}%
548 {\symup{R_{Earth}}}%
549 {6.4\timestento{6}}{6.3781\timestento{6}}%
550 {\meter}%
551 \newphysicalconstant{earthsundistance}%
552 {\symup{d_{ES}}}%
553 {1.5\timestento{11}}{1.496\timestento{11}}%
554 {\meter}%
555 \newphysicalconstant{electroncharge}%
556 {\symup{q_e}}%
557 {-\elementarychargeapproximatevalue}{-\elementarychargeprecisevalue}%
558 {\ampere\usk\second}%
559 [\coulomb]%
560 [\coulomb]%
561 \newphysicalconstant{electronCharge}%
562 {\symup{Q_e}}%
563 {-\elementarychargeapproximatevalue}{-\elementarychargeprecisevalue}%
564 {\ampere\usk\second}%
565 [\coulomb]%
566 [\coulomb]%
567 \newphysicalconstant{electronmass}%
568 {\symup{m_e}}%
569 {9.1\timestento{-31}}{9.1093837015\timestento{-31}}%
570 {\kilogram}%
571 \newphysicalconstant{elementarycharge}%
572 {\symup{e}}%
573 {1.6\timestento{-19}}{1.602176634\timestento{-19}}% % exact 2019 value
574 {\ampere\usk\second}%
575 [\coulomb]%
576 [\coulomb]%
577 \newphysicalconstant{finestructure}%
578 {\symup{\alpha}}%
579 {\frac{1}{137}}{7.2973525693\timestento{-3}}%
580 {}%
581 \newphysicalconstant{hydrogenmass}%
582 {\symup{m_H}}%
583 {1.7\timestento{-27}}{1.6737236\timestento{-27}}%
584 {\kilogram}%
585 \newphysicalconstant{moonearthdistance}%
586 {\symup{d_{ME}}}%
587 {3.8\timestento{8}}{3.81550\timestento{8}}%
588 {\meter}%
589 \newphysicalconstant{moonmass}%
590 {\symup{M_{Moon}}}%

```



```

591 {7.3\timestento{22}}{7.342\timestento{22}}%
592 {\kilogram}%
593 \newphysicalconstant{moonradius}%
594 {\symup{R_{Moon}}}%
595 {1.7\timestento{6}}{1.7371\timestento{6}}%
596 {\meter}%
597 \newphysicalconstant{mzofp}%
598 {\symup{\frac{\mu_o}{4\pi}}}%
599 {\tento{-7}}{\tento{-7}}%
600 {\kilogram\usk\meter\usk\ampere\totheinversetwo\usk\second\totheinversetwo}%
601 [\henry\per\meter]%
602 [\tesla\usk\meter\per\ampere]%
603 \newphysicalconstant{neutronmass}%
604 {\symup{m_n}}%
605 {1.7\timestento{-27}}{1.67492749804\timestento{-27}}%
606 {\kilogram}%
607 \newphysicalconstant{oofpez}%
608 {\symup{\frac{1}{4\pi\epsilon_o}}}%
609 {9\timestento{9}}{8.9875517923\timestento{9}}%
610 {\kilogram\usk\meter\tothethree\usk\ampere\totheinversetwo\usk\second\totheinversefour}%
611 [\meter\per\farad]%
612 [\newton\usk\meter\tothetwo\per\coulomb\tothetwo]%
613 \newphysicalconstant{oofpezcs}%
614 {\symup{\frac{1}{4\pi\epsilon_o c^2}}}%
615 {\tento{-7}}{\tento{-7}}%
616 {\kilogram\usk\meter\usk\ampere\totheinversetwo\usk\second\totheinversetwo}%
617 [\tesla\usk\meter\tothetwo]%
618 [\newton\usk\second\tothetwo\per\coulomb\tothetwo]%
619 \newphysicalconstant{planck}%
620 {\symup{h}}%
621 {6.6\timestento{-34}}{6.62607015\timestento{-34}}% % exact 2019 value
622 {\kilogram\usk\meter\tothetwo\usk\second\inverse}%
623 [\joule\usk\second]%
624 [\joule\usk\second]%

```

See <https://tex.stackexchange.com/a/448565/218142>.

```

625 \newphysicalconstant{planckbar}%
626 {\symup{\lower0.18ex\hbox{\mathchar"AF\mkern-7mu h}}}%
627 {1.1\timestento{-34}}{1.054571817\timestento{-34}}%
628 {\kilogram\usk\meter\tothetwo\usk\second\inverse}%
629 [\joule\usk\second]%
630 [\joule\usk\second]
631 \newphysicalconstant{planckc}%
632 {\symup{hc}}%
633 {2.0\timestento{-25}}{1.98644586\timestento{-25}}%
634 {\kilogram\usk\meter\tothethree\usk\second\totheinversetwo}%
635 [\joule\usk\meter]%
636 [\joule\usk\meter]%
637 \newphysicalconstant{protoncharge}%
638 {\symup{q_p}}%
639 {+\elementarychargeapproximatevalue}{+\elementarychargeprecisevalue}%
640 {\ampere\usk\second}%
641 [\coulomb]%
642 [\coulomb]%
643 \newphysicalconstant{protonCharge}%
644 {\symup{Q_p}}%
645 {+\elementarychargeapproximatevalue}{+\elementarychargeprecisevalue}%
646 {\ampere\usk\second}%
647 [\coulomb]%

```

```

648 [\coulomb]%
649 \newphysicalconstant{protonmass}%
650 {\symup{m_p}}%
651 {1.7\timestento{-27}}{1.672621898\timestento{-27}}%
652 {\kilogram}%
653 \newphysicalconstant{rydberg}%
654 {\symup{R_{\infty}}}%
655 {1.1\timestento{7}}{1.0973731568160\timestento{7}}%
656 {\meter\inverse}%
657 \newphysicalconstant{speedoflight}%
658 {\symup{c}}%
659 {3\timestento{8}}{2.99792458\timestento{8}}% % exact value
660 {\meter\usk\second\inverse}%
661 [\meter\per\second]%
662 [\meter\per\second]
663 \newphysicalconstant{stefanboltzmann}%
664 {\symup{\sigma}}%
665 {5.7\timestento{-8}}{5.670374\timestento{-8}}%
666 {\kilogram\usk\second\totheinversethree\usk\kelvin\totheinversefour}%
667 [\watt\per\meter\tothetwo\usk\kelvin\tothefour]%
668 [\watt\per\meter\tothetwo\usk\kelvin\tothefour]
669 \newphysicalconstant{sunearthdistance}%
670 {\symup{d_{SE}}}%
671 {1.5\timestento{11}}{1.496\timestento{11}}%
672 {\meter}%
673 \newphysicalconstant{sunmass}%
674 {\symup{M_{Sun}}}%
675 {2.0\timestento{30}}{1.98855\timestento{30}}%
676 {\kilogram}%
677 \newphysicalconstant{sunradius}%
678 {\symup{R_{Sun}}}%
679 {7.0\timestento{8}}{6.957\timestento{8}}%
680 {\meter}%
681 \newphysicalconstant{surfacegravfield}%
682 {\symup{g}}%
683 {9.8}{9.807}%
684 {\meter\usk\second\totheinversetwo}%
685 [\newton\per\kilogram]%
686 [\newton\per\kilogram]%
687 \newphysicalconstant{universalgrav}%
688 {\symup{G}}%
689 {6.7\timestento{-11}}{6.67430\timestento{-11}}%
690 {\meter\tothethree\usk\kilogram\inverse\usk\second\totheinversetwo}%
691 [\newton\usk\meter\tothetwo\per\kilogram\tothetwo]% % also \joule\usk\meter\per\kilogram\tothetwo
692 [\newton\usk\meter\tothetwo\per\kilogram\tothetwo]%
693 \newphysicalconstant{vacuumpermeability}%
694 {\symup{\mu_o}}%
695 {4\pi\timestento{-7}}{4\pi\timestento{-7}}% % as of 2018 no longer 4\pi\timestento{-7}
696 {\kilogram\usk\meter\usk\ampere\totheinversetwo\usk\second\totheinversetwo}%
697 [\henry\per\meter]%
698 [\tesla\usk\meter\per\ampere]%
699 \newphysicalconstant{vacuumpermittivity}%
700 {\symup{\epsilon_o}}%
701 {9\timestento{-12}}{8.854187817\timestento{-12}}%
702 {\ampere\tothetwo\usk\second\tothefour\usk\kilogram\inverse\usk\meter\totheinversethree}%
703 [\farad\per\meter]%
704 [\coulomb\tothetwo\per\newton\usk\meter\tothetwo]%

```

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

```

705 \NewDocumentCommand{\checkquantity}{ m }{%
706   % Works for both scalar and vector quantities.
707   \begin{center}
708     \begin{tabular}{>{\bfseries\small}p{0.5\linewidth} p{0.1\linewidth} p{0.1\linewidth} p{0.1\linewidth}}
709       name & & \tabularnewline
710       \ttfamily\footnotesize{\expandafter\string\csname #1\endcsname} & & \tabularnewline
711     \end{tabular}
712     \begin{tabular}{>{\small}p{0.25\linewidth} >{\small}p{0.25\linewidth} >{\small}p{0.25\linewidth}}
713       base & derived & alternate \tabularnewline
714       \footnotesize{\csname #1onlybaseunits\endcsname} &
715       \footnotesize{\csname #1onlyderivedunits\endcsname} &
716       \footnotesize{\csname #1onlyalternateunits\endcsname}
717     \end{tabular}
718   \end{center}
719 }%
720 \NewDocumentCommand{\checkconstant}{ m }{%
721   \begin{center}
722     \begin{tabular}{>{\bfseries\small}p{0.5\linewidth} p{0.1\linewidth} p{0.1\linewidth} p{0.1\linewidth}}
723       name & & \tabularnewline
724       \ttfamily\footnotesize{\expandafter\string\csname #1\endcsname} & & \tabularnewline
725     \end{tabular}
726     \begin{tabular}{>{\small}p{0.25\linewidth} >{\small}p{0.25\linewidth} >{\small}p{0.25\linewidth}}
727       base & approximate & precise \tabularnewline
728       \footnotesize{\csname #1mathsymbol\endcsname} &
729       \footnotesize{\csname #1approximatevalue\endcsname} &
730       \footnotesize{\csname #1precisevalue\endcsname}
731     \end{tabular}
732     \begin{tabular}{>{\small}p{0.25\linewidth} >{\small}p{0.25\linewidth} >{\small}p{0.25\linewidth}}
733       base & derived & alternate \tabularnewline
734       \footnotesize{\csname #1onlybaseunits\endcsname} &
735       \footnotesize{\csname #1onlyderivedunits\endcsname} &
736       \footnotesize{\csname #1onlyalternateunits\endcsname}
737     \end{tabular}
738   \end{center}
739 }%

```

`\mivector`<sup>P.37</sup> is a workhorse command. Original code provided by @egreg.  
 See <https://tex.stackexchange.com/a/39054/218142>.

```

740 \ExplSyntaxOn
741 \NewDocumentCommand{\mivector}{ O{,} m o }{%
742   {%
743     \mi_vector:nn { #1 } { #2 }
744     \IfValueT{#3}{\;{#3}}
745   }%
746   \seq_new:N \l__mi_list_seq
747   \cs_new_protected:Npn \mi_vector:nn #1 #2
748   {%
749     \ensuremath{%
750       \seq_set_split:Nnn \l__mi_list_seq { , } { #2 }
751       \int_compare:nF { \seq_count:N \l__mi_list_seq = 1 } { \left\langle
752         \seq_use:Nnnn \l__mi_list_seq { #1 } { #1 } { #1 }
753         \int_compare:nF { \seq_count:N \l__mi_list_seq = 1 } { \right\rangle
754       }%
755     }%
756 \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

**`\vec{<symbol>}[<labels>]`** (use this variant for boldface notation)  
**`\vec*{<symbol>}[<labels>]`** (use this variant for arrow notation)

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

<code>\( \vec{p} \)</code>	<code>\\</code>	$\mathbf{p}$
<code>\( \vec{p}_{2} \)</code>	<code>\\</code>	$\mathbf{p}_{\text{ball}}$
<code>\( \vec{p}^{\symup{ball}} \)</code>	<code>\\</code>	$\mathbf{p}^{\text{ball}}$
<code>\( \vec{p}_{\symup{final}} \)</code>	<code>\\</code>	$\mathbf{p}_{\text{ball}}^{\text{final}}$
<code>\( \vec{p}^{\symup{ball}}_{\symup{final}} \)</code>	<code>\\</code>	$\mathbf{p}_{\text{ball}}^{\text{final}}$
<code>\( \vec{p}^{\symup{final}}_{\symup{ball}} \)</code>	<code>\\</code>	$\mathbf{p}_{\text{ball}}^{\text{final}}$
<code>\( \vec*{p} \)</code>		$\vec{p}$

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

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

<code>\( \dirvec{p} \)</code>	<code>\\</code>	$\hat{\mathbf{p}}$
<code>\( \dirvec{p}_{2} \)</code>	<code>\\</code>	$\hat{\mathbf{p}}_{\text{ball}}$
<code>\( \dirvec{p}^{\symup{ball}} \)</code>	<code>\\</code>	$\hat{\mathbf{p}}^{\text{ball}}$
<code>\( \dirvec{p}_{\symup{final}} \)</code>	<code>\\</code>	$\hat{\mathbf{p}}_{\text{ball}}^{\text{final}}$
<code>\( \dirvec{p}^{\symup{ball}}_{\symup{final}} \)</code>	<code>\\</code>	$\hat{\mathbf{p}}_{\text{ball}}^{\text{final}}$
<code>\( \dirvec{p}^{\symup{final}}_{\symup{ball}} \)</code>	<code>\\</code>	$\hat{\mathbf{p}}_{\text{ball}}^{\text{final}}$
<code>\( \dirvec*{p} \)</code>		$\vec{\hat{p}}$

**`\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.

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

$$\vec{0}$$

`\direction[\langle delimiter \rangle]{\langle c_1, \dots, c_n \rangle}`

`\unitvector[\langle delimiter \rangle]{\langle c_1, \dots, c_n \rangle}`

Semantic aliases for `\mivector` → P.37.

`\direction{\frac{1}{\sqrt{3}}, \frac{1}{\sqrt{3}}, \frac{1}{\sqrt{3}}} \`  
`\unitvector{\frac{1}{\sqrt{3}}, \frac{1}{\sqrt{3}}, \frac{1}{\sqrt{3}}}`

$$\left\langle \frac{1}{\sqrt{3}}, \frac{1}{\sqrt{3}}, \frac{1}{\sqrt{3}} \right\rangle$$

`\changein`

Semantic alias for `\Delta`.

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

$$\Delta t$$

$$\Delta p$$

`\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)

`\anglebrackets[\langle size \rangle]{\langle quantity \rangle}`

(angle brackets)

`\anglebrackets*[\langle size \rangle]{\langle quantity \rangle}`

(angle brackets for fractions)

`\parentheses[\langle size \rangle]{\langle quantity \rangle}`

(parentheses)

`\parentheses*[\langle size \rangle]{\langle 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)

`\curlybraces*[\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.

`\[ \doublebars{ } \]`  
`\[ \doublebars{\vec{a}} \]`  
`\[ \doublebars*{\frac{\vec{a}}{3}} \]`  
`\[ \doublebars[\Bigg]{\frac{\vec{a}}{3}} \]`

$$\| \cdot \|$$

$$\| a \|$$

$$\left\| \frac{a}{3} \right\|$$

$$\left\| \frac{a}{3} \right\|$$

$\backslash[ \backslash\mathrm{singlebars}\{ \} \backslash]$ $\backslash[ \backslash\mathrm{singlebars}\{x\} \backslash]$ $\backslash[ \backslash\mathrm{singlebars}\{*\frac{x}{3}\} \backslash]$ $\backslash[ \backslash\mathrm{singlebars}[\mathrm{Bigg}]{*\frac{x}{3}} \backslash]$	$ \cdot $ $ x $ $\left \frac{x}{3}\right $ $\left \frac{x}{3}\right $
$\backslash[ \backslash\mathrm{anglebrackets}\{ \} \backslash]$ $\backslash[ \backslash\mathrm{anglebrackets}\{\mathrm{vec}\{a\}\} \backslash]$ $\backslash[ \backslash\mathrm{anglebrackets}\{*\frac{\mathrm{vec}\{a\}}{3}\} \backslash]$ $\backslash[ \backslash\mathrm{anglebrackets}[\mathrm{Bigg}]{*\frac{\mathrm{vec}\{a\}}{3}} \backslash]$	$\langle\cdot\rangle$ $\langle a\rangle$ $\left\langle\frac{a}{3}\right\rangle$ $\left\langle\frac{a}{3}\right\rangle$
$\backslash[ \backslash\mathrm{parentheses}\{ \} \backslash]$ $\backslash[ \backslash\mathrm{parentheses}\{x\} \backslash]$ $\backslash[ \backslash\mathrm{parentheses}\{*\frac{x}{3}\} \backslash]$ $\backslash[ \backslash\mathrm{parentheses}[\mathrm{Bigg}]{*\frac{x}{3}} \backslash]$	$(\cdot)$ $(x)$ $\left(\frac{x}{3}\right)$ $\left(\frac{x}{3}\right)$
$\backslash[ \backslash\mathrm{squarebrackets}\{ \} \backslash]$ $\backslash[ \backslash\mathrm{squarebrackets}\{x\} \backslash]$ $\backslash[ \backslash\mathrm{squarebrackets}\{*\frac{x}{3}\} \backslash]$ $\backslash[ \backslash\mathrm{squarebrackets}[\mathrm{Bigg}]{*\frac{x}{3}} \backslash]$	$[\cdot]$ $[x]$ $\left[\frac{x}{3}\right]$ $\left[\frac{x}{3}\right]$

```
\[ \curlybraces{} \]
\[ \curlybraces{x} \]
\[ \curlybraces*{\frac{x}{3}} \]
\[ \curlybraces[\Big]{\frac{x}{3}} \]
```

$$\{\cdot\}$$

$$\{x\}$$

$$\left\{\frac{x}{3}\right\}$$

$$\left\{\frac{x}{3}\right\}$$

N 2021-02-21

`\magnitude` $[\langle size \rangle]{\langle quantity \rangle}$  (alias for double bars)

N 2021-02-21

`\magnitude*` $[\langle size \rangle]{\langle quantity \rangle}$  (alias for double bars for fractions)

N 2021-02-21

`\norm` $[\langle size \rangle]{\langle quantity \rangle}$  (alias for double bars)

N 2021-02-21

`\norm*` $[\langle size \rangle]{\langle quantity \rangle}$  (alias for double bars for fractions)

N 2021-02-21

`\absolutevalue` $[\langle size \rangle]{\langle quantity \rangle}$  (alias for single bars)

N 2021-02-21

`\absolutevalue*` $[\langle size \rangle]{\langle quantity \rangle}$  (alias for single bars for fractions)

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

```
\[ \magnitude{\vec{p}} \]
\[ \magnitude{\vec{*p}} \]
\[ \magnitude*{\vec{p}_{\symup{final}}} \]
\[ \magnitude*{\vec{*p}_{\symup{final}}} \]
```

$$\|\mathbf{p}\|$$

$$\|\vec{p}\|$$

$$\|\mathbf{p}_{\text{final}}\|$$

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

N 2021-04-06

`\parallelto`

N 2021-04-06

`\perpendicularto`

Commands for geometric relationships, mainly intended for subscripts.

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

$$\mathbf{F}_{\parallel} + \mathbf{F}_{\perp}$$

## 4.2 Problems and Annotated Problem Solutions

N 2021-02-03

`\begin{physicsproblem}` $\{\langle title \rangle\}$  (use this variant for vertical lists)  
 $\langle problem \rangle$

`\end{physicsproblem}`

N 2021-02-03

`\begin{physicsproblem*}` $\{\langle title \rangle\}$  (use this variant for in-line lists)  
 $\langle problem \rangle$

`\end{physicsproblem*}`

N 2021-02-03

`\begin{parts}` $\{\langle title \rangle\}$  (provides problem parts)  
 $\langle problem \rangle$

`\end{parts}`

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

**\problem part**

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}
    \problem part This is the first part.
    \problem part This is the second part.
    \problem part This is the third part.
  \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}
    \problem part This is the first part.
    \problem part This is the second part.
    \problem part 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.



`\begin{physicssolution}` (use this variant for numbered steps)  
`\end{physicssolution}`

`\begin{physicssolution*}` (use this variant for unnumbered steps)  
`\end{physicssolution*}`

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

```
\begin{physicssolution}
  x &= y + z \\
  z &= x - y \\
  y &= x - z \\
\end{physicssolution}
\begin{physicssolution*}
  x &= y + z \\
  z &= x - y \\
  y &= x - z \\
\end{physicssolution*}
```

$$x = y + z \quad (1)$$

$$z = x - y \quad (2)$$

$$y = x - z \quad (3)$$

$$x = y + z$$

$$z = x - y$$

$$y = x - z$$

`\reason{<reason>}`

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

```
\begin{physicssolution}
  x &= y + z \reason{This is a reason.} \\
  z &= x - y \reason{This is a reason too.} \\
  y &= x - z \reason{final answer} \\
\end{physicssolution}
\begin{physicssolution*}
  x &= y + z \reason{This is a reason.} \\
  z &= x - y \reason{This is a reason too.} \\
  y &= x - z \reason{final answer} \\
\end{physicssolution*}
```

$$x = y + z \quad \text{This is a reason.} \quad (4)$$

$$z = x - y \quad \text{This is a reason too.} \quad (5)$$

$$y = x - z \quad \text{final answer} \quad (6)$$

$$x = y + z \quad \text{This is a reason.}$$

$$z = x - y \quad \text{This is a reason too.}$$

$$y = x - z \quad \text{final answer}$$

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}
    \problem part This is the first part.
    \begin{physicssolution}
      The solution goes here.
    \end{physicssolution}
    \problem part This is the second part.
    \begin{physicssolution}
      The solution goes here.
    \end{physicssolution}
    \problem part This is the third part.
    \begin{physicssolution}
      The solution goes here.
    \end{physicssolution}
  \end{parts}
\end{physicsproblem}

```

N 2021-02-06

**\hilite**[*<color>*]{*<target>*}[*<shape>*]

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{align*}
(\Delta s)^2 &= -(\Delta t)^2 + (\Delta x)^2 + (\Delta y)^2 + \\
&\quad (\Delta z)^2 \\\
(\Delta s)^2 &= \hilite{-(\Delta t)^2 + (\Delta x)^2}{rounded rectangle} + \\
&\quad (\Delta y)^2 + (\Delta z)^2 \\\
(\Delta s)^2 &= \hilite{-(\Delta t)^2 + (\Delta x)^2}{rectangle} + \\
&\quad (\Delta y)^2 + (\Delta z)^2 \\\
(\Delta s)^2 &= \hilite{-(\Delta t)^2 + (\Delta x)^2}{ellipse} + \\
&\quad (\Delta y)^2 + (\Delta z)^2 \\\
(\Delta s)^2 &\hilite{2}{circle} \approx \hilite{green}{-}{circle} \\
&\quad (\Delta t)^2 \hilite{cyan}{2}{circle} + \\
&\quad (\Delta x)^2 \hilite{orange}{2}{circle} + \\
&\quad (\Delta y)^2 \hilite{blue!50}{2}{circle} + \\
&\quad (\Delta z)^2 \hilite{violet!45}{2}{circle}
\end{align*}

```

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

```

\begin{align*}
\Delta\vec{p} &= \vec{F}_{\text{sumup{net}}}\Delta t \\
\Delta\vec{p} &= \vec{F}_{\text{symup{net}}}\Delta t \\
\Delta\vec{p} &= \vec{F}_{\text{symup{net}}}\Delta t \\
\Delta\vec{p} &= \vec{F}_{\text{symup{net}}}\Delta t \\
\Delta\vec{p} &= \vec{F}_{\text{symup{net}}}\Delta t \\
\Delta\vec{p} &= \vec{F}_{\text{symup{net}}}\Delta t \\
\Delta\vec{p} &= \vec{F}_{\text{symup{net}}}\Delta t \\
\Delta\vec{p} &= \vec{F}_{\text{symup{net}}}\Delta t
\end{align*}

```

$$\begin{aligned}
 \Delta p &= F_{\text{net}} \Delta t \\
 \Delta p &= F_{\text{net}} \Delta t \\
 \Delta p &= F_{\text{net}} \Delta t \\
 \Delta p &= F_{\text{net}} \Delta t \\
 \Delta p &= F_{\text{net}} \Delta t \\
 \Delta p &= F_{\text{net}} \Delta t \\
 \Delta p &= F_{\text{net}} \Delta t
 \end{aligned}$$

U 2021-02-26

`\image[options]{caption}{label}{image}`

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

```

\image[scale=0.20]{example-image-1x1}
{Image shown 20 percent actual size.}{refig1}

```



Figure 1: Image shown 20 percent actual size.

Figure `\ref{reffi1}` is nice.  
 It's captioned `\nameref{reffi1}` and is on page `\pageref{reffi1}`.

Figure 1 is nice. It's captioned Image shown 20 percent actual size and is on page 59.

```
\image[scale=0.20,angle=45]{example-image-1x1}
{Image shown 20 percent actual size and rotated.}{reffi1}
```

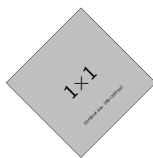


Figure 2: Image shown 20 percent actual size and rotated.

Figure `\ref{reffi2}` is nice.  
 It's captioned `\nameref{reffi2}` and is on page `\pageref{reffi2}`.

Figure 2 is nice. It's captioned Image shown 20 percent actual size and rotated and is on page 60.

### 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.

```
\colvec[⟨delimiter⟩]{⟨c1, ..., cn⟩}
\rowvec[⟨delimiter⟩]{⟨c1, ..., cn⟩}
```

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.

```
\[ \colvec{1,2,3} \]
\[ \rowvec{1,2,3} \]
\[ \colvec{x_0,x_1,x_2,x_3} \]
\[ \rowvec{x^0,x^1,x^2,x^3} \]
```

$$\begin{pmatrix} 1 \\ 2 \\ 3 \end{pmatrix}$$

$$(1 \ 2 \ 3)$$

$$\begin{pmatrix} x_0 \\ x_1 \\ x_2 \\ x_3 \end{pmatrix}$$

$$(x^0 \ x^1 \ x^2 \ x^3)$$

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

Conforms to ISO 80000-2 notation.

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

***r***  
*r*  
***r***  
*r*

`\valence{index}{index}`  
`\valence*{index}{index}`

Typesets tensor valence. The starred variant typesets it horizontally.

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

A vector is a  $\binom{1}{0}$  tensor.  
A vector is a  $(1,0)$  tensor.

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

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

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

$\mathbb{C}_{1,2}$   
 $\mathbb{C}_{1,2}$

`\slot[vector]`  
`\slot*[vector]`

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

```

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

```

$$\left( \underline{\quad} \right)$$

$$\left( \underline{a} \right)$$

$$\left( \quad \right)$$

$$\left( a \right)$$

N 2021-04-06

**\diff**

Intelligent differential (exterior derivative) operator.

```

\[
\int x \, dx
\]
\[
\int x \, \diff{x}
\]
\[
\int x \, \diff*[x]
\]

```

$$\int x \, dx$$

$$\int x \, dx$$

$$\int x \, dx$$

## 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 `glowscripblock` Environment

U 2021-02-26

```

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

```

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>3</sup><https://glowsript.org>

<sup>4</sup><https://vpython.org>

```

\begin{glowscripblock}(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{glowscripblock}

```

## GlowScript Program 1: A GlowScript Program

```

1  GlowScript 3.0 vpython
2
3  scene.width = 400
4  scene.height = 760
5  # constants and data
6  g = 9.8          # m/s^2
7  mball = 0.03     # kg
8  Lo = 0.26        # m
9  ks = 1.8         # N/m
10 deltatt = 0.01   # s
11
12 # objects (origin is at ceiling)
13 ceiling = box(pos=vector(0,0,0), length=0.2, height=0.01,
14               width=0.2)
15 ball = sphere(pos=vector(0,-0.3,0), radius=0.025,
16               color=color.orange)
17 spring = helix(pos=ceiling.pos, axis=ball.pos-ceiling.pos,
18               color=color.cyan, thickness=0.003, coils=40,
19               radius=0.010)
20
21 # initial values
22 pball = mball * vector(0,0,0)      # kg m/s
23 Fgrav = mball * g * vector(0,-1,0) # N
24 t = 0
25
26 # improve the display
27 scene.autoscale = False           # turn off automatic camera zoom
28 scene.center = vector(0,-Lo,0)    # move camera down
29 scene.waitfor('click')            # wait for a mouse click
30
31 # initial calculation loop
32 # calculation loop
33 while t < 10:
34     rate(100)
35     # we need the stretch
36     s = mag(ball.pos) - Lo
37     # we need the spring force
38     Fspring = ks * s * -norm(spring.axis)
39     Fnet = Fgrav + Fspring
40     pball = pball + Fnet * deltatt
41     ball.pos = ball.pos + (pball / mball) * deltatt
42     spring.axis = ball.pos - ceiling.pos
43     t = t + deltatt

```

\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 64.



## 4.6 The `vpythonfile` Command

U 2021-02-26

`\vpythonfile` [*<options>*] {*<file>*} {*<caption>*}

Command to load and typeset a `VPython` program. The file is read from {*<file>*}. 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

```

1  from vpython import *
2
3  scene.width = 400
4  scene.height = 760
5  # constants and data
6  g = 9.8          # m/s^2
7  mball = 0.03     # kg
8  Lo = 0.26        # m
9  ks = 1.8         # N/m
10 deltatt = 0.01   # s
11
12 # objects (origin is at ceiling)
13 ceiling = box(pos=vector(0,0,0), length=0.2, height=0.01,
14               width=0.2)
15 ball = sphere(pos=vector(0,-0.3,0), radius=0.025,
16               color=color.orange)
17 spring = helix(pos=ceiling.pos, axis=ball.pos-ceiling.pos,
18               color=color.cyan, thickness=0.003, coils=40,
19               radius=0.010)
20
21 # initial values
22 pball = mball * vector(0,0,0)      # kg m/s
23 Fgrav = mball * g * vector(0,-1,0) # N
24 t = 0
25
26 # improve the display
27 scene.autoscale = False            # turn off automatic camera zoom
28 scene.center = vector(0,-Lo,0)     # move camera down
29 scene.waitfor('click')             # wait for a mouse click
30
31 # initial calculation loop
32 # calculation loop
33 while t < 10:
34     rate(100)
35     # we need the stretch
36     s = mag(ball.pos) - Lo
37     # we need the spring force
38     Fspring = ks * s * -norm(spring.axis)
39     Fnet = Fgrav + Fspring
40     pball = pball + Fnet * deltatt
41     ball.pos = ball.pos + (pball / mball) * deltatt
42     spring.axis = ball.pos - ceiling.pos
43     t = t + deltatt

```

\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 66.

## 4.7 The `glowscriptinline` and `vpythoninline` Commands

U 2021-02-26

U 2021-02-26

```
\glowscriptinline{\i{GlowScript code}}
```

```
\vpythoninline{\i{VPython code}}
```

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

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

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

## 4.8 mandistudent Source Code

Define 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.

```

757 \def\mandistudent@Version{3.0.0m}
758 \def\mandistudent@Date{2021-05-28}
759 \NeedsTeXFormat{LaTeX2e}[1999/12/01]
760 \providecommand\DeclareRelease[3]{}
761 \providecommand\DeclareCurrentRelease[2]{}
762 \DeclareRelease{v3.0.0m}{2021-05-28}{mandistudent.sty}
763 \DeclareCurrentRelease{v\mandi@Version}{\mandi@Date}
764 \ProvidesPackage{mandistudent}
765 [\mandistudent@Date\space v\mandistudent@Version\space Macros for introductory physics]

```

Define a convenient package version command.

```

766 \newcommand*{\mandistudentversion}{v\mandistudent@Version\space dated \mandistudent@Date}

```

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

```

767 \RequirePackage{amsmath}           % AMS goodness (don't load amssymb or amsfonts)
768 \RequirePackage{inline}{enumitem} % needed for physicsproblem environment
769 \RequirePackage{eso-pic}           % needed for \hilite
770 \RequirePackage{g}{esvect}         % needed for nice vector arrow, style g
771 \RequirePackage{pgfplots}          % needed for key-value interface
772 \RequirePackage{iftex}             % needed for requiring LuaLaTeX
773 \RequirePackage{makebox}           % needed for consistent \dirvect; \makebox
774 \RequirePackage{mathtools}         % needed for paired delimiters; extends amsmath
775 \RequirePackage{nicematrix}        % needed for column and row vectors
776 \RequirePackage{most}{tcolorbox}   % needed for program listings
777 \RequirePackage{tensor}            % needed for index notation
778 \RequirePackage{tikz}              % needed for \hilite
779 \usetikzlibrary{shapes,fit,tikzmark} % needed for \hilite
780 \RequirePackage{unicode-math}       % needed for Unicode support
781 \RequirePackage{hyperref}           % load last
782 \RequireLuaTeX                     % require this engine

```

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 L<sup>A</sup>T<sub>E</sub>X kernel. Because `unicode-math` is required, all documents using `mandi` must be compiled with an engine that supports Unicode. We recommend LuaL<sup>A</sup>T<sub>E</sub>X.

```

783 \unimathsetup{math-style=ISO}
784 \unimathsetup{warnings-off={mathtools-colon,mathtools-overbracket}}
785 %
786 % Use normal math letters from Latin Modern Math for familiarity with
787 % textbooks.
788 %
789 % \begin{macrocode}
790 \setmathfont[Scale=MatchLowercase]
791 {Latin Modern Math} % default math font; better J

```

Borrow from GeX Gyre DejaVu Math for vectors and tensors to get single-storey g.

```

792 \setmathfont[Scale=MatchLowercase,range={sfup/{latin},bfsfup/{latin}}]
793 {TeX Gyre DejaVu Math} % single-storey lowercase g

```

Borrow from GeX Gyre DejaVu Math to get single-storey g.

```

794 \setmathfont[Scale=MatchLowercase,range={sfup/{latin},bfsfup/{latin}}]
795 {TeX Gyre DejaVu Math} % single-storey lowercase g

```

Borrow `mathscr` and `mathbfscr` from XITS Math.

See <https://tex.stackexchange.com/a/120073/218142>.

```

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

```

Get original and bold mathcal fonts.  
See <https://tex.stackexchange.com/a/21742/218142>.

```
797 \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.

```
798 \setmathfont[Scale=MatchLowercase,range={"E17C-"E1F6}]{STIX Two Math}
799 \newfontfamily{\symsfgreek}{STIX Two Math}
800 % I don't understand why \text{...} is necessary.
801 \newcommand{\symsfupalpha}      {\text{\symsfgreek{~~~~e196}}}
802 \newcommand{\symsfupbeta}      {\text{\symsfgreek{~~~~e197}}}
803 \newcommand{\symsfupgamma}     {\text{\symsfgreek{~~~~e198}}}
804 \newcommand{\symsfupdelta}     {\text{\symsfgreek{~~~~e199}}}
805 \newcommand{\symsfupepsilon}   {\text{\symsfgreek{~~~~e1af}}}
806 \newcommand{\symsfupvarepsilon}{\text{\symsfgreek{~~~~e19a}}}
807 \newcommand{\symsfupzeta}      {\text{\symsfgreek{~~~~e19b}}}
808 \newcommand{\symsfupeta}       {\text{\symsfgreek{~~~~e19c}}}
809 \newcommand{\symsfuptheta}     {\text{\symsfgreek{~~~~e19d}}}
810 \newcommand{\symsfupvartheta}  {\text{\symsfgreek{~~~~e1b0}}}
811 \newcommand{\symsfupiota}      {\text{\symsfgreek{~~~~e19e}}}
812 \newcommand{\symsfupkappa}     {\text{\symsfgreek{~~~~e19f}}}
813 \newcommand{\symsfuplambda}    {\text{\symsfgreek{~~~~e1a0}}}
814 \newcommand{\symsfupmu}        {\text{\symsfgreek{~~~~e1a1}}}
815 \newcommand{\symsfupnu}        {\text{\symsfgreek{~~~~e1a2}}}
816 \newcommand{\symsfupxi}        {\text{\symsfgreek{~~~~e1a3}}}
817 \newcommand{\symsfupomicron}  {\text{\symsfgreek{~~~~e1a4}}}
818 \newcommand{\symsfuppi}        {\text{\symsfgreek{~~~~e1a5}}}
819 \newcommand{\symsfupvarpi}     {\text{\symsfgreek{~~~~e1b3}}}
820 \newcommand{\symsfuprho}       {\text{\symsfgreek{~~~~e1a6}}}
821 \newcommand{\symsfupvarrho}    {\text{\symsfgreek{~~~~e1b2}}}
822 \newcommand{\symsfupsigma}     {\text{\symsfgreek{~~~~e1a8}}}
823 \newcommand{\symsfupvarsigma} {\text{\symsfgreek{~~~~e1a7}}}
824 \newcommand{\symsfuptau}       {\text{\symsfgreek{~~~~e1a9}}}
825 \newcommand{\symsfupupsilon}   {\text{\symsfgreek{~~~~e1aa}}}
826 \newcommand{\symsfupphi}       {\text{\symsfgreek{~~~~e1b1}}}
827 \newcommand{\symsfupvarphi}    {\text{\symsfgreek{~~~~e1ab}}}
828 \newcommand{\symsfupchi}       {\text{\symsfgreek{~~~~e1ac}}}
829 \newcommand{\symsfuppsi}       {\text{\symsfgreek{~~~~e1ad}}}
830 \newcommand{\symsfupomega}     {\text{\symsfgreek{~~~~e1ae}}}
831 \newcommand{\symsfupDelta}     {\text{\symsfgreek{~~~~e180}}}
832 \newcommand{\symsfupGamma}    {\text{\symsfgreek{~~~~e17f}}}
833 \newcommand{\symsfupTheta}     {\text{\symsfgreek{~~~~e18e}}}
834 \newcommand{\symsfupLambda}    {\text{\symsfgreek{~~~~e187}}}
835 \newcommand{\symsfupXi}        {\text{\symsfgreek{~~~~e18a}}}
836 \newcommand{\symsfupPi}        {\text{\symsfgreek{~~~~e18c}}}
837 \newcommand{\symsfupSigma}     {\text{\symsfgreek{~~~~e18f}}}
838 \newcommand{\symsfupUpsilon}   {\text{\symsfgreek{~~~~e191}}}
839 \newcommand{\symsfupPhi}       {\text{\symsfgreek{~~~~e192}}}
840 \newcommand{\symsfupPsi}       {\text{\symsfgreek{~~~~e194}}}
841 \newcommand{\symsfupOmega}     {\text{\symsfgreek{~~~~e195}}}
842 \newcommand{\symsfitalpha}     {\text{\symsfgreek{~~~~e1d8}}}
843 \newcommand{\symsfitbeta}      {\text{\symsfgreek{~~~~e1d9}}}
844 \newcommand{\symsfitgamma}     {\text{\symsfgreek{~~~~e1da}}}
845 \newcommand{\symsfitdelta}     {\text{\symsfgreek{~~~~e1db}}}
846 \newcommand{\symsfitepsilon}   {\text{\symsfgreek{~~~~e1f1}}}
847 \newcommand{\symsfitvarepsilon}{\text{\symsfgreek{~~~~e1dc}}}
848 \newcommand{\symsfitzeta}      {\text{\symsfgreek{~~~~e1dd}}}
849 \newcommand{\symsfitaeta}      {\text{\symsfgreek{~~~~e1de}}}
```

```

850 \newcommand{\symsfittheta} {\text{\symsfgreek{~~~~e1df}}}
851 \newcommand{\symsfitvartheta} {\text{\symsfgreek{~~~~e1f2}}}
852 \newcommand{\symsfitiota} {\text{\symsfgreek{~~~~e1e0}}}
853 \newcommand{\symsfitkappa} {\text{\symsfgreek{~~~~e1e1}}}
854 \newcommand{\symsfitlambda} {\text{\symsfgreek{~~~~e1e2}}}
855 \newcommand{\symsfitmu} {\text{\symsfgreek{~~~~e1e3}}}
856 \newcommand{\symsfitnu} {\text{\symsfgreek{~~~~e1e4}}}
857 \newcommand{\symsfitxi} {\text{\symsfgreek{~~~~e1e5}}}
858 \newcommand{\symsfitomicron} {\text{\symsfgreek{~~~~e1e6}}}
859 \newcommand{\symsfitpi} {\text{\symsfgreek{~~~~e1e7}}}
860 \newcommand{\symsfitvarpi} {\text{\symsfgreek{~~~~e1f5}}}
861 \newcommand{\symsfitrho} {\text{\symsfgreek{~~~~e1e8}}}
862 \newcommand{\symsfitvarrho} {\text{\symsfgreek{~~~~e1f4}}}
863 \newcommand{\symsfitsigma} {\text{\symsfgreek{~~~~e1ea}}}
864 \newcommand{\symsfitvarsigma} {\text{\symsfgreek{~~~~e1e9}}}
865 \newcommand{\symsfittau} {\text{\symsfgreek{~~~~e1eb}}}
866 \newcommand{\symsfitupsilon} {\text{\symsfgreek{~~~~e1ec}}}
867 \newcommand{\symsfitphi} {\text{\symsfgreek{~~~~e1f3}}}
868 \newcommand{\symsfitvarphi} {\text{\symsfgreek{~~~~e1ed}}}
869 \newcommand{\symsfitchi} {\text{\symsfgreek{~~~~e1ee}}}
870 \newcommand{\symsfitpsi} {\text{\symsfgreek{~~~~e1ef}}}
871 \newcommand{\symsfitomega} {\text{\symsfgreek{~~~~e1f0}}}
872 \newcommand{\symsfitDelta} {\text{\symsfgreek{~~~~e1c2}}}
873 \newcommand{\symsfitGamma} {\text{\symsfgreek{~~~~e1c1}}}
874 \newcommand{\symsfitTheta} {\text{\symsfgreek{~~~~e1d0}}}
875 \newcommand{\symsfitLambda} {\text{\symsfgreek{~~~~e1c9}}}
876 \newcommand{\symsfitXi} {\text{\symsfgreek{~~~~e1cc}}}
877 \newcommand{\symsfitPi} {\text{\symsfgreek{~~~~e1ce}}}
878 \newcommand{\symsfitSigma} {\text{\symsfgreek{~~~~e1d1}}}
879 \newcommand{\symsfitUpsilon} {\text{\symsfgreek{~~~~e1d3}}}
880 \newcommand{\symsfitPhi} {\text{\symsfgreek{~~~~e1d4}}}
881 \newcommand{\symsfitPsi} {\text{\symsfgreek{~~~~e1d6}}}
882 \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>.

```

883 \DeclareFontFamily{U}{esvect}{}
884 \DeclareFontShape{U}{esvect}{m}{n}{%
885   <-5.5> vect5
886   <5.5-6.5> vect6
887   <6.5-7.5> vect7
888   <7.5-8.5> vect8
889   <8.5-9.5> vect9
890   <9.5-> vect10
891 }{}%

```

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

```

892 \typeout{}%
893 \typeout{mandistudent: You are using mandistudent \mandistudentversion.}%
894 \typeout{mandistudent: This package requires LuaLaTeX.}%
895 \typeout{mandistudent: This package changes the default math font(s).}%
896 \typeout{mandistudent: This package redefines the \protect\vec\space command.}%
897 \typeout{}%

```

A better, intelligent coordinate-free `\vec`<sup>P. 52</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 <https://tex.stackexchange.com/q/554706/218142>.  
 See also <https://tex.stackexchange.com/a/531037/218142>.

```

898 \RenewDocumentCommand{\vec}{ s m e_{_}^ }{%
899   \ensuremath{%
900     % Note the \, used to make superscript look better.
901     \IfBooleanTF {#1}
902       {\vv{#2}%      % * gives an arrow
903         % Use \sp{} primitive for superscript.
904         % Adjust superscript for the arrow.
905         \sp{\IfValueT{#4}{\,\,#4}\vphantom{\smash[t]{\big|}}}}
906       }%
907     {\symbfit{#2} % no * gives us bold
908       % Use \sp{} primitive for superscript.
909       % No superscript adjustment needed.
910       \sp{\IfValueT{#4}{#4}\vphantom{\smash[t]{\big|}}}}
911     }%
912     % Use \sb{} primitive for subscript.
913     \sb{\IfValueT{#3}{#3}\vphantom{\smash[b]{|}}}}
914   }%
915 }%

```

A command for the direction of a vector. We use a slight tweak to get uniform hats that requires the [makebox](https://tex.stackexchange.com/a/391204/218142) package.  
 See <https://tex.stackexchange.com/a/391204/218142>.

```

916 \NewDocumentCommand{\dirvec}{ s m e_{_}^ }{%
917   \ensuremath{%
918     \widehat{\makebox*{\(w\)}{\ensuremath{%
919       \IfBooleanTF {#1}
920         {%
921           #2
922         }%
923         {%
924           \symbfit{#2}
925         }%
926         }%
927       }%
928     \sb{\IfValueT{#3}{#3}\vphantom{\smash[b]{|}}}}
929     \sp{\IfValueT{#4}{\,\,#4}\vphantom{\smash[t]{\big|}}}}
930   }%
931 }%
932 }%

```

The zero vector.

```

933 \NewDocumentCommand{\zerovec}{ s }{%
934   \IfBooleanTF {#1}
935     {\vv{0}}%
936     {\symbfup{0}}%
937 }%

```

Notation for column and row vectors. Original code provided by @egreg.  
 See <https://tex.stackexchange.com/a/39054/218142>.

```

938 \ExplSyntaxOn
939 \NewDocumentCommand{\colvec}{ O{,} m }{%
940   \vector_main:nnnn { p } { \ } { #1 } { #2 }
941 }%
942 \NewDocumentCommand{\rowvec}{ O{,} m }{%
943   \vector_main:nnnn { p } { & } { #1 } { #2 }
944 }%
945 \seq_new:N \l__vector_arg_seq

```

```

946 \cs_new_protected:Npn \vector_main:nnnn #1 #2 #3 #4 {%
947   \seq_set_split:Nnn \l__vector_arg_seq { #3 } { #4 }
948   \begin{#1NiceMatrix}[r]
949     \seq_use:Nnnn \l__vector_arg_seq { #2 } { #2 } { #2 }
950   \end{#1NiceMatrix}
951 }%
952 \ExplSyntaxOff

```

Semantic aliases for `\mivector`<sup>P.37</sup>.

```

953 \NewDocumentCommand{\direction}{}{\mivector}
954 \NewDocumentCommand{\unitvector}{}{\mivector}

```

Students always need this symbol.

```

955 \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.

```

956 \DeclarePairedDelimiterX{\doublebars}[1]{\lVert}{\rVert}{\ifblank{#1}{\:\cdot\:}{#1}}
957 \DeclarePairedDelimiterX{\singlebars}[1]{\lvert}{\rvert}{\ifblank{#1}{\:\cdot\:}{#1}}
958 \DeclarePairedDelimiterX{\anglebrackets}[1]{\langle}{\rangle}{\ifblank{#1}{\:\cdot\:}{#1}}
959 \DeclarePairedDelimiterX{\parentheses}[1]{(}{)}{\ifblank{#1}{\:\cdot\:}{#1}}
960 \DeclarePairedDelimiterX{\squarebrackets}[1]{\lbrack}{\rbrack}{\ifblank{#1}{\:\cdot\:}{#1}}
961 \DeclarePairedDelimiterX{\curlybraces}[1]{\lbrace}{\rbrace}{\ifblank{#1}{\:\cdot\:}{#1}}

```

Important semantic aliases.

Some semantic aliases. Because of the way `\vec`<sup>P.52</sup> and `\dirvec`<sup>P.52</sup> are defined, I reluctantly decided not to implement a `\magvec` command. It would require accounting for too many options. So `\magnitude`<sup>P.55</sup> is the new solution.

```

962 \NewDocumentCommand{\magnitude}{}{\doublebars}
963 \NewDocumentCommand{\norm}{}{\doublebars}
964 \NewDocumentCommand{\absolutevalue}{}{\singlebars}

```

Commands for two important geometric relationships. These are meant mainly to be subscripts.

```

965 \NewDocumentCommand{\parallelto}{}
966   {\mkern3mu\vphantom{\perp}\vrule depth 0pt\mkern2mu\vrule depth 0pt\mkern3mu}
967 \NewDocumentCommand{\perpendicularto}{}
968   {\perp}

```

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

```

969 \NewDocumentEnvironment{physicsproblem}{ m }{%
970   \newpage%
971   \section*{#1}%
972   \newlist{parts}{enumerate}{2}%
973   \setlist[parts]{label=\bfseries(\alph*)}%
974   { }%
975 \NewDocumentEnvironment{physicsproblem*}{ m }{%
976   \newpage%
977   \section*{#1}%
978   \newlist{parts}{enumerate*}{2}%
979   \setlist[parts]{label=\bfseries(\alph*)}%
980   { }%
981 \NewDocumentCommand{\problempart}{}{\item}%

```

An environment for problem solutions.

```

982 \NewDocumentEnvironment{physicssolution}{ +b }{%
983   % Make equation numbering consecutive through the document.
984   \begin{align}
985     #1
986   \end{align}
987 }{%

```



```

988 \NewDocumentEnvironment{physicssolution*}{ +b }{%
989 % Make equation numbering consecutive through the document.
990 \begin{align*}
991 #1
992 \end{align*}
993 }{%

```

See <https://tex.stackexchange.com/q/570223/218142>.

```

994 \NewDocumentCommand{\reason}{ 0{4cm} m }
995 {&&\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>.

```

996 \newcounter{tikzhighlightnode}
997 \NewDocumentCommand{\hilite}{ 0{magenta!60} m 0{rectangle} }{%
998 \stepcounter{tikzhighlightnode}%
999 \tikzmarknode{highlighted-node-\number\value{tikzhighlightnode}}{#2}%
1000 \edef\temp{%
1001 \noexpand\AddToShipoutPictureBG{%
1002 \noexpand\begin{tikzpicture}[overlay,remember picture]%
1003 \noexpand\iftikzmarkconcurrentpage{highlighted-node-\number\value{tikzhighlightnode}}%
1004 \noexpand\node[inner sep=1.0pt,fill=#1,#3,fit=(highlighted-node-\number\value{tikzhighlightnode})]{};%
1005 \noexpand\fi
1006 \noexpand\end{tikzpicture}%
1007 }%
1008 }%
1009 \temp%
1010 }%

```

A simplified command for importing images.

```

1011 \NewDocumentCommand{\image}{ 0{scale=1} m m m }{%
1012 \begin{figure}[ht!]
1013 \begin{center}%
1014 \includegraphics[#1]{#2}%
1015 \end{center}%
1016 \caption{#3}%
1017 \label{#4}%
1018 \end{figure}%
1019 }%

```

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.

```

1020 \NewDocumentCommand{\veccomp}{ s m }{%
1021 % Consider renaming this to \vectorsym.
1022 \IfBooleanTF{#1}
1023 {%
1024 \ensuremath{\symnormal{#2}}%
1025 }%
1026 {%
1027 \ensuremath{\symbfit{#2}}%
1028 }%

```

```

1029 }%
1030 \NewDocumentCommand{\tencomp}{ s m }{%
1031   % Consider renaming this to \tensororsym.
1032   \IfBooleanTF{#1}
1033   {%
1034     \ensuremath{\symsfit{#2}}%
1035   }%
1036   {%
1037     \ensuremath{\symbfsfit{#2}}%
1038   }%
1039 }%

Command to typeset tensor valence.

1040 \NewDocumentCommand{\valence}{ s m m }{%
1041   \IfBooleanTF{#1}
1042   {(#2,#3)}
1043   {\binom{#2}{#3}}
1044 }%

Intelligent notation for contraction on pairs of slots.

1045 \NewDocumentCommand{\contraction}{ s m }{%
1046   \IfBooleanTF{#1}
1047   {\mathsf{C}}%
1048   {\sybbb{C}}%
1049   _{#2}
1050 }%

Intelligent slot command for coordinate-free tensor notation.

1051 \NewDocumentCommand{\slot}{ s d[] }{%
1052   % d[] must be used because of the way consecutive optional
1053   % arguments are handled. See xparse docs for details.
1054   \IfBooleanTF{#1}
1055   {%
1056     \IfValueTF{#2}
1057     {% Insert a vector, but don't show the slot.
1058       \smash{\makebox[1.5em]{\ensuremath{#2}}}
1059     }%
1060     {% No vector, no slot.
1061       \smash{\makebox[1.5em]{\ensuremath{}}}
1062     }%
1063   }%
1064   {%
1065     \IfValueTF{#2}
1066     {% Insert a vector and show the slot.
1067       \underline{\smash{\makebox[1.5em]{\ensuremath{#2}}}}
1068     }%
1069     {% No vector; just show the slot.
1070       \underline{\smash{\makebox[1.5em]{\ensuremath{}}}}
1071     }%
1072   }%
1073 }%

Intelligent differential (exterior derivative) operator.

1074 \NewDocumentCommand{\diff}{ s }{%
1075   \mathop{\!}\!
1076   \IfBooleanTF{#1}
1077   {\sybfsfup{d}}%
1078   {\symsfup{d}}%
1079 }%

```

```

1080 \directlua{%
1081 luaotfload.add_colorscheme("colordigits",
1082   [{"8000FF"} = {"one","two","three","four","five","six","seven","eight","nine","zero"}])
1083 }%
1084 \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>.

```

1085 \newfontfamily\gsfontfamily{DejaVuSansMono} % new font for listings
1086 \definecolor{gsbggray}{rgb}{0.90,0.90,0.90} % background gray
1087 \definecolor{gsgray}{rgb}{0.30,0.30,0.30} % gray
1088 \definecolor{gsgreen}{rgb}{0.00,0.60,0.00} % green
1089 \definecolor{gsorange}{rgb}{0.80,0.45,0.12} % orange
1090 \definecolor{gspeach}{rgb}{1.00,0.90,0.71} % peach
1091 \definecolor{gspearl}{rgb}{0.94,0.92,0.84} % pearl
1092 \definecolor{gsplum}{rgb}{0.74,0.46,0.70} % plum
1093 \lstdefinestyle{vpython}{% % style for listings
1094   backgroundcolor=\color{gsbggray},% % background color
1095   basicstyle=\colordigits\footnotesize,% % default style
1096   breakatwhitespace=true% % break at whitespace
1097   breaklines=true,% % break long lines
1098   captionpos=b,% % position caption
1099   classoffset=1,% % STILL DON'T UNDERSTAND THIS
1100   commentstyle=\color{gsgray},% % font for comments
1101   deletekeywords={print},% % delete keywords from the given language
1102   emph={self,cls,@classmethod,@property},% % words to emphasize
1103   emphstyle=\color{gsorange}\itshape,% % font for emphasis
1104   escapeinside={(*@}{*@)},% % add LaTeX within your code
1105   frame=tb,% % frame style
1106   framerule=2.0pt,% % frame thickness
1107   framexleftmargin=5pt,% % extra frame left margin
1108   %identifierstyle=\sffamily,% % style for identifiers
1109   keywordstyle=\gsfontfamily\color{gsplum},% % color for keywords
1110   language=Python,% % select language
1111   linewidth=\linewidth,% % width of listings
1112   morekeywords={% % VPython/GlowScript specific keywords
1113     __future__,abs,acos,align,ambient,angle,append,append_to_caption,%
1114     append_to_title,arange,arrow,asin,astuple,atan,atan2,attach_arrow,%
1115     attach_trail,autoscale,axis,background,billboard,bind,black,blue,border,%
1116     bounding_box,box,bumpaxis,bumpmap,bumpmaps,camera,canvas,caption,capture,%
1117     ceil,center,clear,clear_trail,click,clone,CoffeeScript,coils,color,combin,%
1118     comp,compound,cone,convex,cos,cross,curve,cyan,cylinder,data,degrees,del,%
1119     delete,depth,descender,diff_angle,digits,division,dot,draw_complete,%
1120     ellipsoid,emissive,end_face_color,equals,explog,extrusion,faces,factorial,%
1121     False,floor,follow,font,format,forward,fov,frame,gcurve,gdisplay,gdots,%
1122     get_library,get_selected,ghbars,global,GlowScript,graph,graphs,green,gvbars,%
1123     hat,headlength,headwidth,height,helix,hsv_to_rgb,index,interval,keydown,%
1124     keyup,label,length,lights,line,linecolor,linewidth,logx,logy,lower_left,%
1125     lower_right,mag,mag2,magenta,make_trail,marker_color,markers,material,%
1126     max,min,mouse,mousedown,mousemove,mouseup,newball,norm,normal,objects,%
1127     offset,one,opacity,orange,origin,path,pause,pi,pixel_to_world,pixels,plot,%
1128     points,pos,pow,pps,print,print_function,print_options,proj,purple,pyramid,%
1129     quad,radians,radius,random,rate,ray,read_local_file,readonly,red,redraw,%
1130     retain,rgb_to_hsv,ring,rotate,round,scene,scroll,shaftwidth,shape,shapes,%
1131     shininess,show_end_face,show_start_face,sign,sin,size,size_units,sleep,%
1132     smooth,space,sphere,sqrt,start,start_face_color,stop,tan,text,textpos,%
1133     texture,textures,thickness,title,trail_color,trail_object,trail_radius,%
1134     trail_type,triangle,trigger,True,twist,unbind,up,upper_left,upper_right,%

```

```

1135     userpan,userspin,userzoom,vec,vector,vertex,vertical_spacing,visible,%
1136     visual,vpython,VPython,waitfor,white,width,world,xtitle,yellow,yoffset,%
1137     ytitle%
1138 },%
1139 morekeywords={print,None,TypeError},%      % additional keywords
1140 morestring=[b]{"""},%                     % treat triple quotes as strings
1141 numbers=left,%                           % where to put line numbers
1142 numbersep=10pt,%                         % how far line numbers are from code
1143 numberstyle=\bfseries\tiny,%             % set to 'none' for no line numbers
1144 showstringspaces=false,%                 % show spaces in strings
1145 showtabs=false,%                         % show tabs within strings
1146 stringstyle=\gsfontfamily\color{gsgreen},% % color for strings
1147 upquote=true,%                           % how to typeset quotes
1148 }%

```

Introduce a new, more intelligent [glowscriptblock](#)<sup>P.62</sup> environment.

```

1149 \NewTCBListing[auto counter,list inside=gsprogs]{glowscriptblock}
1150 { 0{ } D(){glowscript.org} m }{%
1151 breakable,%
1152 center,%
1153 code = \newpage,%
1154 %derivpeach,%
1155 enhanced,%
1156 hyperurl interior = https://#2,%
1157 label = {gs:\thetcbcounter},%
1158 left = 8mm,%
1159 list entry = \thetcbcounter~~~~~#3,%
1160 listing only,%
1161 listing style = vpython,%
1162 nameref = {#3},%
1163 title = \texttt{GlowScript} Program \thetcbcounter: #3,%
1164 width = 0.9\textwidth,%
1165 {#1},
1166 }%

```

A new command for generating a list of GlowScript programs.

```

1167 \NewDocumentCommand{\listofglowscriptprograms}{-}{\tcblistof[\section*]{gsprogs}
1168 {List of \texttt{GlowScript} Programs}}%

```

Introduce a new, more intelligent [\vpythonfile](#)<sup>P.65</sup> command.

```

1169 \NewTCBInputListing[auto counter,list inside=vpprog]{\vpythonfile}
1170 { 0{ } m m }{%
1171 breakable,%
1172 center,%
1173 code = \newpage,%
1174 %derivgray,%
1175 enhanced,%
1176 hyperurl interior = https://,%
1177 label = {vp:\thetcbcounter},%
1178 left = 8mm,%
1179 list entry = \thetcbcounter~~~~~#3,%
1180 listing file = {#2},%
1181 listing only,%
1182 listing style = vpython,%
1183 nameref = {#3},%
1184 title = \texttt{VPython} Program \thetcbcounter: #3,%
1185 width = 0.9\textwidth,%
1186 {#1},%
1187 }%

```

A new command for generating a list of VPython programs.

```
1188 \NewDocumentCommand{\listofvpythonprograms}{\tcblistof[\section*]{vpprogs}  
1189 {List of \texttt{VPython} Programs}}%
```

Introduce a new `\glowsriptinline`<sup>P.67</sup> command.

```
1190 \DeclareTotalTCBox{\glowsriptinline}{ m }{%  
1191   bottom = Opt,%  
1192   bottomrule = 0.0mm,%  
1193   boxsep = 1.0mm,%  
1194   colback = gsbgray,%  
1195   colframe = gsbgray,%  
1196   left = Opt,%  
1197   leftrule = 0.0mm,%  
1198   nobeforeafter,%  
1199   right = Opt,%  
1200   rightrule = 0.0mm,%  
1201   sharp corners,%  
1202   tcbox raise base,%  
1203   top = Opt,%  
1204   toprule = 0.0mm,%  
1205 }\lstinline[style = vpython]{#1}}%
```

Define `\vpythoninline`<sup>P.67</sup>, a semantic alias for VPython in-line listings.

```
1206 \NewDocumentCommand{\vpythoninline}{\glowsriptinline}%
```

## 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 Fundamental Principles

<code>\lhsmomentumprinciple</code>	(LHS of delta form, bold vectors)
<code>\rhsmomentumprinciple</code>	(RHS of delta form, bold vectors)
<code>\lhsmomentumprincipleupdate</code>	(LHS of update form, bold vectors)
<code>\rhsmomentumprincipleupdate</code>	(RHS of update form, bold vectors)
<code>\momentumprinciple</code>	(delta form, bold vectors)
<code>\momentumprincipleupdate</code>	(update form, bold vectors)
<code>\lhsmomentumprinciple*</code>	(LHS of delta form, arrow vectors)
<code>\rhsmomentumprinciple*</code>	(RHS of delta form, arrow vectors)
<code>\lhsmomentumprincipleupdate*</code>	(LHS of update form, arrow vectors)
<code>\rhsmomentumprincipleupdate*</code>	(RHS of update form, arrow vectors)
<code>\momentumprinciple*</code>	(delta form, arrow vectors)
<code>\momentumprincipleupdate*</code>	(update form, arrow vectors)

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

```

\(\ \lhsmomentumprinciple \)      \\\
\(\ \rhsmomentumprinciple \)      \\\
\(\ \lhsmomentumprincipleupdate \) \\\
\(\ \rhsmomentumprincipleupdate \) \\\
\(\ \momentumprinciple \)         \\\
\(\ \momentumprincipleupdate \)   \\\
\(\ \lhsmomentumprinciple* \)     \\\
\(\ \rhsmomentumprinciple* \)     \\\
\(\ \lhsmomentumprincipleupdate* \) \\\
\(\ \rhsmomentumprincipleupdate* \) \\\
\(\ \momentumprinciple* \)        \\\
\(\ \momentumprincipleupdate* \)  \\\

```

$$\begin{aligned}
&\Delta \mathbf{p}_{\text{sys}} \\
&\mathbf{F}_{\text{sys,net}} \Delta t \\
&\mathbf{p}_{\text{sys,final}} \\
&\mathbf{p}_{\text{sys,initial}} + \mathbf{F}_{\text{sys,net}} \Delta t \\
&\Delta \mathbf{p}_{\text{sys}} = \mathbf{F}_{\text{sys,net}} \Delta t \\
&\mathbf{p}_{\text{sys,final}} = \mathbf{p}_{\text{sys,initial}} + \mathbf{F}_{\text{sys,net}} \Delta t \\
&\Delta \vec{p}_{\text{sys}} \\
&\vec{F}_{\text{sys,net}} \Delta t \\
&\vec{p}_{\text{sys,final}} \\
&\vec{p}_{\text{sys,initial}} + \vec{F}_{\text{sys,net}} \Delta t \\
&\Delta \vec{p}_{\text{sys}} = \vec{F}_{\text{sys,net}} \Delta t \\
&\vec{p}_{\text{sys,final}} = \vec{p}_{\text{sys,initial}} + \vec{F}_{\text{sys,net}} \Delta t
\end{aligned}$$

<code>\lhsenergyprinciple</code>	(LHS of delta form)
<code>\rhsenergyprinciple[(&lt;+process...&gt;)]</code>	(RHS of delta form)
<code>\lhsenergyprincipleupdate</code>	(LHS of update form)
<code>\rhsenergyprincipleupdate[(&lt;+process...&gt;)]</code>	(RHS of update form)
<code>\energyprinciple[(&lt;+process...&gt;)]</code>	(delta form)

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

`\energyprincipleupdate[(<+process...>)]`

(update form)

Variants of command for typesetting the energy principle.

```
\( \lhsenergyprinciple \)      \\
\(\ \rhsenergyprinciple \)      \\
\(\ \rhsenergyprinciple[+Q] \)  \\
\(\ \energyprinciple \)         \\
\(\ \energyprinciple[+Q] \)     \\
\(\ \lhsenergyprincipleupdate \) \\
\(\ \rhsenergyprincipleupdate \) \\
\(\ \rhsenergyprincipleupdate[+Q] \) \\
\(\ \energyprincipleupdate \)   \\
\(\ \energyprincipleupdate[+Q] \)
```

$$\begin{aligned} &\Delta E_{\text{sys}} \\ &W_{\text{ext}} \\ &W_{\text{ext}} + Q \\ &\Delta E_{\text{sys}} = W_{\text{ext}} \\ &\Delta E_{\text{sys}} = W_{\text{ext}} + Q \\ &E_{\text{sys,final}} \\ &E_{\text{sys,initial}} + W_{\text{ext}} \\ &E_{\text{sys,initial}} + W_{\text{ext}} + Q \\ &E_{\text{sys,final}} = E_{\text{sys,initial}} + W_{\text{ext}} \\ &E_{\text{sys,final}} = E_{\text{sys,initial}} + W_{\text{ext}} + Q \end{aligned}$$

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

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

```
\( \lhsangularmomentumprinciple \)      \\
\(\ \rhsangularmomentumprinciple \)      \\
\(\ \lhsangularmomentumprincipleupdate \) \\
\(\ \rhsangularmomentumprincipleupdate \) \\
\(\ \angularmomentumprinciple \)         \\
\(\ \angularmomentumprincipleupdate \)   \\
\(\ \lhsangularmomentumprinciple* \)     \\
\(\ \rhsangularmomentumprinciple* \)     \\
\(\ \lhsangularmomentumprincipleupdate* \) \\
\(\ \rhsangularmomentumprincipleupdate* \) \\
\(\ \angularmomentumprinciple* \)        \\
\(\ \angularmomentumprincipleupdate* \)
```

$$\begin{aligned} &\Delta \mathbf{L}_{A,\text{sys,net}} \\ &\boldsymbol{\tau}_{A,\text{sys,net}} \Delta t \\ &\mathbf{L}_{A,\text{sys,final}} \\ &\mathbf{L}_{A,\text{sys,initial}} + \boldsymbol{\tau}_{A,\text{sys,net}} \Delta t \\ &\Delta \mathbf{L}_{A,\text{sys,net}} = \boldsymbol{\tau}_{A,\text{sys,net}} \Delta t \\ &\mathbf{L}_{A,\text{sys,final}} = \mathbf{L}_{A,\text{sys,initial}} + \boldsymbol{\tau}_{A,\text{sys,net}} \Delta t \\ &\vec{\mathbf{L}}_{A,\text{sys,net}} \\ &\vec{\boldsymbol{\tau}}_{A,\text{sys,net}} \Delta t \\ &\vec{\mathbf{L}}_{A,\text{sys,final}} \\ &\vec{\mathbf{L}}_{A,\text{sys,initial}} + \vec{\boldsymbol{\tau}}_{A,\text{sys,net}} \Delta t \\ &\Delta \vec{\mathbf{L}}_{A,\text{sys,net}} = \vec{\boldsymbol{\tau}}_{A,\text{sys,net}} \Delta t \\ &\vec{\mathbf{L}}_{A,\text{sys,final}} = \vec{\mathbf{L}}_{A,\text{sys,initial}} + \vec{\boldsymbol{\tau}}_{A,\text{sys,net}} \Delta t \end{aligned}$$

## 5.2 Other Expressions

N 2021-02-13

**\energyof** $\langle label \rangle$  $[\langle label \rangle]$

Generic symbol for the energy of some entity.

$\langle \backslash \text{energyof} \{ \text{sympup{electron}} \} \rangle \backslash \backslash$   
 $\langle \backslash \text{energyof} \{ \text{sympup{electron}} \} [ \text{sympup{final}} ] \rangle \backslash$

$E_{\text{electron}}$   
 $E_{\text{electron,final}}$

N 2021-02-13

**\systemenergy** $[\langle label \rangle]$

Symbol for system energy.

$\langle \backslash \text{systemenergy} \rangle \backslash \backslash$   
 $\langle \backslash \text{systemenergy} [ \text{sympup{final}} ] \rangle \backslash$

$E_{\text{sys}}$   
 $E_{\text{sys,final}}$

N 2021-02-13

**\particleenergy** $[\langle label \rangle]$

Symbol for particle energy.

$\langle \backslash \text{particleenergy} \rangle \backslash \backslash$   
 $\langle \backslash \text{particleenergy} [ \text{sympup{final}} ] \rangle \backslash$

$E_{\text{particle}}$   
 $E_{\text{particle,final}}$

N 2021-02-13

**\restenergy** $\langle label \rangle$

Symbol for rest energy.

$\langle \backslash \text{restenergy} \rangle \backslash \backslash$   
 $\langle \backslash \text{restenergy} [ \text{sympup{final}} ] \rangle \backslash$

$E_{\text{rest}}$   
 $E_{\text{rest,final}}$

N 2021-02-13

**\internalenergy** $[\langle label \rangle]$

Symbol for internal energy.

$\langle \backslash \text{internalenergy} \rangle \backslash \backslash$   
 $\langle \backslash \text{internalenergy} [ \text{sympup{final}} ] \rangle \backslash$

$E_{\text{internal}}$   
 $E_{\text{internal,final}}$

N 2021-02-13

**\chemicalenergy** $[\langle label \rangle]$

Symbol for chemical energy.

$\langle \backslash \text{chemicalenergy} \rangle \backslash \backslash$   
 $\langle \backslash \text{chemicalenergy} [ \text{sympup{final}} ] \rangle \backslash$

$E_{\text{chem}}$   
 $E_{\text{chem,final}}$

N 2021-02-13

**\thermalenergy** $[\langle label \rangle]$

Symbol for thermal energy.



`\( \thermalenergy \) \`  
`\( \thermalenergy[\symup{final}] \)`

$E_{\text{therm}}$   
 $E_{\text{therm,final}}$

N 2021-02-13

`\photonenergy[\langle label \rangle]`

Symbol for photon energy.

`\( \photonenergy \) \`  
`\( \photonenergy[\symup{final}] \)`

$E_{\text{photon}}$   
 $E_{\text{photon,final}}$

N 2021-02-13

`\translationalkineticenergy[\langle label \rangle]`

N 2021-02-13

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

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

`\( \translationalkineticenergy \) \`  
`\( \translationalkineticenergy[\symup{initial}] \) \`  
`\( \translationalkineticenergy* \) \`  
`\( \translationalkineticenergy*[\symup{initial}] \)`

$K_{\text{trans}}$   
 $K_{\text{trans,initial}}$   
 $E_{\text{K}}$   
 $E_{\text{K,initial}}$

N 2021-02-13

`\rotationalkineticenergy[\langle label \rangle]`

N 2021-02-13

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

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

`\( \rotationalkineticenergy \) \`  
`\( \rotationalkineticenergy[\symup{initial}] \) \`  
`\( \rotationalkineticenergy* \) \`  
`\( \rotationalkineticenergy*[\symup{initial}] \)`

$K_{\text{rot}}$   
 $K_{\text{rot,initial}}$   
 $E_{\text{rot}}$   
 $E_{\text{rot,initial}}$

N 2021-02-13

`\vibrationalkineticenergy[\langle label \rangle]`

N 2021-02-13

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

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

`\( \vibrationalkineticenergy \) \`  
`\( \vibrationalkineticenergy[\symup{initial}] \) \`  
`\( \vibrationalkineticenergy* \) \`  
`\( \vibrationalkineticenergy*[\symup{initial}] \)`

$K_{\text{vib}}$   
 $K_{\text{vib,initial}}$   
 $E_{\text{vib}}$   
 $E_{\text{vib,initial}}$

N 2021-02-13

`\gravitationalpotentialenergy[\langle label \rangle]`

Symbol for gravitational potential energy.

`\( \gravitationalpotentialenergy \) \`  
`\( \gravitationalpotentialenergy[\symup{final}] \)`

$U_{\text{g}}$   
 $U_{\text{g,final}}$

N 2021-02-13

**\electricpotentialenergy**[*\langle label \rangle*]

Symbol for electric potential energy.

```
\( \electricpotentialenergy \) \\  
\( \electricpotentialenergy[\symup{final}] \)
```

$U_e$   
 $U_{e,\text{final}}$

N 2021-02-13

**\springpotentialenergy**[*\langle label \rangle*]

Symbol for spring potential energy.

```
\( \springpotentialenergy \) \\  
\( \springpotentialenergy[\symup{final}] \)
```

$U_s$   
 $U_{s,\text{final}}$

### 5.3 mandiexp Source Code

Define 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.

```

1207 \def\mandiexp@Version{3.0.0m}
1208 \def\mandiexp@Date{2021-05-28}
1209 \NeedsTeXFormat{LaTeX2e}[1999/12/01]
1210 \providecommand\DeclareRelease[3]{}
1211 \providecommand\DeclareCurrentRelease[2]{}
1212 \DeclareRelease{v3.0.0m}{2021-05-28}{mandiexp.sty}
1213 \DeclareCurrentRelease{v\mandiexp@Version}{\mandiexp@Date}
1214 \ProvidesPackage{mandiexp}
1215 [\mandiexp@Date\space v\mandiexp@Version\space Macros for Matter & Interactions]

```

Define a convenient package version command.

```

1216 \newcommand*{\mandiexpversion}{v\mandiexp@Version\space dated \mandiexp@Date}

1217 \RequirePackage{mandi}
1218 %
1219 \typeout{}%
1220 \typeout{mandiexp: You are using mandiexp \mandiexpversion.}
1221 \typeout{mandiexp: This package requires LuaLaTeX.}%
1222 \typeout{}%
1223 %
1224 % Commands specific to Matter & Interactions
1225 % The momentum principle
1226 \NewDocumentCommand{\lhsmomentumprinciple}{ s }{%
1227   \Delta
1228   \IfBooleanTF{#1}%
1229     {\vec*{p}}%
1230     {\vec{p}}%
1231   _{\symup{sys}}}%
1232 }%
1233 \NewDocumentCommand{\rhsmomentumprinciple}{ s }{%
1234   \IfBooleanTF{#1}%
1235     {\vec*{F}}%
1236     {\vec{F}}%
1237   _{\symup{sys,net}}\,\Delta t%
1238 }%
1239 \NewDocumentCommand{\lhsmomentumprincipleupdate}{ s }{%
1240   \IfBooleanTF{#1}%
1241     {\vec*{p}}%
1242     {\vec{p}}%
1243   _{\symup{sys,final}}}%
1244 }%
1245 \NewDocumentCommand{\rhsmomentumprincipleupdate}{ s }{%
1246   \IfBooleanTF{#1}%
1247     {\vec*{p}}%
1248     {\vec{p}}%
1249   _{\symup{sys,initial}}+}%
1250   \IfBooleanTF{#1}%
1251     {\vec*{F}}%
1252     {\vec{F}}%
1253   _{\symup{sys,net}}\,\Delta t%
1254 }%
1255 \NewDocumentCommand{\momentumprinciple}{ s }{%
1256   \IfBooleanTF{#1}%
1257     {\lhsmomentumprinciple* = \rhsmomentumprinciple*}%

```

```

1258     {\lhsmomentumprinciple = \rhsmomentumprinciple}%
1259 }%
1260 \NewDocumentCommand{\momentumprincipleupdate}{s}{%
1261   \IfBooleanTF{#1}%
1262     {\lhsmomentumprincipleupdate* = \rhsmomentumprincipleupdate*}%
1263     {\lhsmomentumprincipleupdate = \rhsmomentumprincipleupdate}%
1264 }%
1265 % The momentum principle
1266 \NewDocumentCommand{\lhsenergyprinciple}{s}{%
1267   \Delta E_{\symup{sys}}%
1268 }%
1269 \NewDocumentCommand{\rhsenergyprinciple}{O{}}{%
1270   W_{\symup{ext}}#1%
1271 }%
1272 \NewDocumentCommand{\lhsenergyprincipleupdate}{s}{%
1273   E_{\symup{sys,final}}%
1274 }%
1275 \NewDocumentCommand{\rhsenergyprincipleupdate}{O{}}{%
1276   E_{\symup{sys,initial}}+%
1277   W_{\symup{ext}}#1%
1278 }%
1279 \NewDocumentCommand{\energyprinciple}{O{}}{%
1280   \lhsenergyprinciple = \rhsenergyprinciple[#1]%
1281 }%
1282 \NewDocumentCommand{\energyprincipleupdate}{O{}}{%
1283   \lhsenergyprincipleupdate = \rhsenergyprincipleupdate[#1]%
1284 }%
1285 % The angular momentum principle
1286 \NewDocumentCommand{\lhsangularmomentumprinciple}{s}{%
1287   \Delta
1288   \IfBooleanTF{#1}%
1289     {\vec{*}{L}}%
1290     {\vec{L}}%
1291   _{A\symup{,sys,net}}%
1292 }%
1293 \NewDocumentCommand{\rhsangularmomentumprinciple}{s}{%
1294   \IfBooleanTF{#1}%
1295     {\vec{*}{\tau}}%
1296     {\vec{\tau}}%
1297   _{A\symup{,sys,net}}\,\Delta t%
1298 }%
1299 \NewDocumentCommand{\lhsangularmomentumprincipleupdate}{s}{%
1300   \IfBooleanTF{#1}%
1301     {\vec{*}{L}}%
1302     {\vec{L}}%
1303   _{A,\symup{sys,final}}%
1304 }%
1305 \NewDocumentCommand{\rhsangularmomentumprincipleupdate}{s}{%
1306   \IfBooleanTF{#1}%
1307     {\vec{*}{L}}%
1308     {\vec{L}}%
1309   _{A\symup{,sys,initial}}+%
1310   \IfBooleanTF{#1}%
1311     {\vec{*}{\tau}}%
1312     {\vec{\tau}}%
1313   _{A\symup{,sys,net}}\,\Delta t%
1314 }%
1315 \NewDocumentCommand{\angularmomentumprinciple}{s}{%
1316   \IfBooleanTF{#1}%

```

```

1317     {\lhsangularmomentumprinciple* = \rhsangularmomentumprinciple*}%
1318     {\lhsangularmomentumprinciple = \rhsangularmomentumprinciple}%
1319 }%
1320 \NewDocumentCommand{\angularmomentumprincipleupdate}{ s }{%
1321   \IfBooleanTF{#1}%
1322     {\lhsangularmomentumprincipleupdate* = \rhsangularmomentumprincipleupdate*}%
1323     {\lhsangularmomentumprincipleupdate = \rhsangularmomentumprincipleupdate}%
1324 }%
1325 \NewDocumentCommand{\energyof}{ m o }{%
1326   E_{#1\IfValueT{#2}{, #2}}%
1327 }%
1328 \NewDocumentCommand{\systemenergy}{ o }{%
1329   E_{\symup{sys}\IfValueT{#1}{, #1}}%
1330 }%
1331 \NewDocumentCommand{\particleenergy}{ o }{%
1332   E_{\symup{particle}\IfValueT{#1}{, #1}}%
1333 }%
1334 \NewDocumentCommand{\restenergy}{ o }{%
1335   E_{\symup{rest}\IfValueT{#1}{, #1}}%
1336 }%
1337 \NewDocumentCommand{\internalenergy}{ o }{%
1338   E_{\symup{internal}\IfValueT{#1}{, #1}}%
1339 }%
1340 \NewDocumentCommand{\chemicalenergy}{ o }{%
1341   E_{\symup{chem}\IfValueT{#1}{, #1}}%
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1343 \NewDocumentCommand{\thermalenergy}{ o }{%
1344   E_{\symup{therm}\IfValueT{#1}{, #1}}%
1345 }%
1346 \NewDocumentCommand{\photonenergy}{ o }{%
1347   E_{\symup{photon}\IfValueT{#1}{, #1}}%
1348 }%
1349 \NewDocumentCommand{\translationalkineticenergy}{ s d[] }{%
1350 % d[] must be used because of the way consecutive optional
1351 % arguments are handled. See xparse docs for details.
1352 % See https://tex.stackexchange.com/a/569011/218142
1353   \IfBooleanTF{#1}%
1354   {E_{\bgroup \symup{K}}}%
1355   {K_{\bgroup \symup{trans}}}%
1356   \IfValueT{#2}{, #2}%
1357   \egroup%
1358 }%
1359 \NewDocumentCommand{\rotationalkineticenergy}{ s d[] }{%
1360 % d[] must be used because of the way consecutive optional
1361 % arguments are handled. See xparse docs for details.
1362 % See https://tex.stackexchange.com/a/569011/218142
1363   \IfBooleanTF{#1}%
1364   {E_{\bgroup}}%
1365   {K_{\bgroup}}%
1366   \symup{rot}\IfValueT{#2}{, #2}%
1367   \egroup%
1368 }%
1369 \NewDocumentCommand{\vibrationalkineticenergy}{ s d[] }{%
1370 % d[] must be used because of the way consecutive optional
1371 % arguments are handled. See xparse docs for details.
1372 % See https://tex.stackexchange.com/a/569011/218142
1373   \IfBooleanTF{#1}%
1374   {E_{\bgroup}}%
1375   {K_{\bgroup}}%

```

```

1376      \symup{vib}\IfValueT{#2}{, #2}%
1377      \egroup%
1378 }%
1379 \NewDocumentCommand{\gravitationalpotentialenergy}{ o }{%
1380   U_{\symup{g}\IfValueT{#1}{, #1}}%
1381 }%
1382 \NewDocumentCommand{\electricpotentialenergy}{ o }{%
1383   U_{\symup{e}\IfValueT{#1}{, #1}}%
1384 }%
1385 \NewDocumentCommand{\springpotentialenergy}{ o }{%
1386   U_{\symup{s}\IfValueT{#1}{, #1}}%
1387 }%

```

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