

# The [mandi](#) Bundle

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mandi version v3.0.2 dated 2021-12-05

mandistudent version v3.0.2 dated 2021-12-05

mandiexp version v3.0.2 dated 2021-12-05

**PLEASE DO NOT DISTRIBUTE THIS BUILD.**

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## Acknowledgements

To all of the students who have learned  $\text{\LaTeX} 2_{\epsilon}$  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  $\text{\LaTeX} 2_{\epsilon}$  developers who inhabit the [TeX StackExchange](#) site. Entering a new culture is daunting for anyone, especially for newcomers; the  $\text{\LaTeX} 2_{\epsilon}$  development culture is no exception. We all share a passion for creating beautiful documents and I have learned much over the summers of 2020 and 2021 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

v3.0.0 (2021-08-22)

<a href="#">mandiexp</a> <sup>→ P.78</sup> Initial release	6
<a href="#">mandi</a> <sup>→ P.8</sup> Initial release	6
<a href="#">mandistudent</a> <sup>→ P.51</sup> Initial release	6

v3.0.1 (2021-08-24)

<a href="#">mandiexp</a> <sup>→ P.78</sup> Minor doc changes	6
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v3.0.2 (2021-12-05)

<a href="#">mandiexp</a> <sup>→ P.78</sup> Code formatted for better readability	83
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<a href="#">mandiexp</a> <sup>→ P.78</sup> xparse is loaded for older formats	83
<a href="#">mandi</a> <sup>→ P.8</sup> Added GitHub links to code	6
<a href="#">mandi</a> <sup>→ P.8</sup> Added <a href="#">\hbar</a> <sup>→ P.33</sup>	45
<a href="#">mandi</a> <sup>→ P.8</sup> Added <a href="#">\lorentzfactor</a> <sup>→ P.16</sup>	43
<a href="#">mandi</a> <sup>→ P.8</sup> Added a negative space to <a href="#">\lightspeed</a> <sup>→ P.32</sup>	37
<a href="#">mandi</a> <sup>→ P.8</sup> Code formatted for better readability	35
<a href="#">mandi</a> <sup>→ P.8</sup> Constants' values now use only <a href="#">\times</a>	46
<a href="#">mandi</a> <sup>→ P.8</sup> Improved <a href="#">\checkconstant</a> <sup>→ P.24</sup>	49
<a href="#">mandi</a> <sup>→ P.8</sup> Improved <a href="#">\checkquantity</a> <sup>→ P.10</sup>	49
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<a href="#">mandi</a> <sup>→ P.8</sup> <a href="#">\mivector</a> <sup>→ P.34</sup> now requires more than one component	50
<a href="#">mandi</a> <sup>→ P.8</sup> xparse is loaded for older formats	35
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# 1 Introduction

The `mandi`<sup>1</sup> bundle consists of three packages: `mandi`, `mandistudent`, and `mandiexp`. Package `mandi` → P.8 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` → P.51 provides other typesetting capability appropriate for written problem solutions. Finally, package `mandiexp` → P.78 provides commands for typesetting expressions from *Matter & Interactions*<sup>2</sup>

`mandi` has been completely rewritten from the ground up. It had gotten too large and clumsy to use and maintain. It (unknowingly) used deprecated packages. It had too many arcane “features” that were never used. It did not support Unicode. It was not compatible with modern engines, like Lua $\text{\LaTeX}$ . It did not have a key-value interface. Options could not be changed on the fly within a document. In short, it was a mess. I hope this rewrite addresses all of the bad things and forms a better code base for maintenance, useability, and future improvements.

So many changes have been made that I think the best approach for former, as well as new, users is to treat this as a brand new experience. I think the most important thing to keep in mind is that I assume users, especially new users, will have a relatively recent TeX distribution (like TeX Live) that includes a recently updated  $\text{\LaTeX}$  2 $\epsilon$  kernel. If users report that this is a major problem, I can provide some degree of backwards compatibility. However, I use a fully updated TeX Live distribution.

## 2 Code Availability

The `mandi` source repository’s `main` branch is at <https://github.com/heafnerj/mandi>. This code will usually coincide with that found on CTAN. The very latest build can be found on the `dev` branch found at <https://github.com/heafnerj/mandi/tree/dev>. Students and other academic users should probably get the `dev` branch code since it is stable and may contain improvements over the `main` branch code.

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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.

### 3 Student/Instructor Quick Guide

Use `\vec`<sup>P.51</sup> to typeset the symbol for a vector. Use `\magnitude`<sup>P.54</sup> to typeset the symbol for a vector's magnitude. Use `\dirvec`<sup>P.51</sup> to typeset the symbol for a vector's direction. Use `\changein`<sup>P.52</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.34</sup> to typeset scientific notation.

<code>\( \vec{p} \)</code> or <code>\( \vec{*p} \)</code>	<code>\</code>	$p$ or $\vec{p}$
<code>\( \vec{p}_{\text{final}} \)</code> or <code>\( \vec{*p}_{\text{final}} \)</code>	<code>\</code>	$p_{\text{final}}$ or $\vec{p}_{\text{final}}$
<code>\( \text{magnitude}\vec{p} \)</code> or <code>\( \text{magnitude*}\vec{p}_{\text{final}} \)</code>	<code>\</code>	$\ p\ $ or $\ p_{\text{final}}\ $
<code>\( \text{dirvec}\vec{p} \)</code> or <code>\( \text{dirvec*}\vec{p} \)</code>	<code>\</code>	$\hat{p}$ or $\hat{p}$
<code>\( \text{changein}\vec{p} \)</code> or <code>\( \text{changein } t \)</code>	<code>\</code>	$\Delta p$ or $\Delta t$
<code>\( \text{zerovec} \)</code> or <code>\( \text{zerovec*} \)</code>	<code>\</code>	$\mathbf{0}$ or $\vec{0}$
<code>\( 6.02\text{timestento}\{-19\} \)</code>		$6.02 \times 10^{-19}$

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.

<code>\( \text{momentum}\{7.071\} \)</code>	<code>\</code>	$7.071 \text{ kg} \cdot \text{m/s}$
<code>\( \text{vectormomentum}\{3,-4,5\} \)</code>	<code>\</code>	$\langle 3, -4, 5 \rangle \text{ kg} \cdot \text{m/s}$
<code>\( \text{momentumvector}\{3,-4,5\} \)</code>		$\langle 3, -4, 5 \rangle \text{ kg} \cdot \text{m/s}$

Use a `physical constant's`<sup>P.23</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.30</sup> and its variant.

<code>\( \text{vacuumpermittivitymathsymbol} = \text{vacuumpermittivity} \)</code>	<code>\</code>	$\epsilon_0 = 9 \times 10^{-12} \text{ C}^2/\text{N} \cdot \text{m}^2$
--	----------------	--

Use `\mivector`<sup>P.34</sup> to typeset symbolic vectors with components. Use the aliases `\direction`<sup>P.13</sup> to typeset a direction or unit vector.

<code>\( \text{mivector}\{\text{slot},\text{slot},\text{slot}\} \)</code> or <code>\( \text{mivector}\{p_x,p_y,p_z\} \)</code>	<code>\</code>	
<code>\( \text{direction}\{\frac{1}{\sqrt{3}},\frac{1}{\sqrt{3}},\frac{1}{\sqrt{3}}\} \)</code> or		
$\langle \frac{1}{\sqrt{3}}, \frac{1}{\sqrt{3}}, \frac{1}{\sqrt{3}} \rangle$ or $\langle p_x, p_y, p_z \rangle$		

Use `physicsproblem`<sup>P.55</sup> and `parts`<sup>P.55</sup> and `\problempart`<sup>P.55</sup> for problems. For step-by-step mathematical solutions use `physicssolution`<sup>P.56</sup>. Use `webvpythonblock`<sup>P.61</sup> to typeset Web VPython programs. Use `\vpythonfile`<sup>P.64</sup> to typeset VPython program files.

## 4 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 v3.0.2 dated 2021-12-05 and is a stable build.

### 4.1 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**.

### 4.2 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}
```

### 4.3 Lua<sup>A</sup>T<sub>E</sub>X is Required

In order to make use of better fonts and Unicode features, **mandi** now requires the Lua<sup>A</sup>T<sub>E</sub>X engine for processing documents. It will not work with other engines.



## 4.4 Physical Quantities

### 4.4.1 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>\momentumvalue{5}</code>	<code>\momentumbaseunits{5}</code>	<code>\momentumderivedunits{5}</code>	<code>\momentumalternateunits{5}</code>	<code>\momentumvector{2,3,4}</code>	<code>\vectormomentum{2,3,4}</code>	<code>\momentum{\mivector{2,3,4}}</code>	<code>\momentumonlybaseunits</code>	<code>\momentumonlyderivedunits</code>	<code>\momentumonlyalternateunits</code>	<code>\momentumvectorvalue{2,3,4}</code>	<code>\vectormomentumvalue{2,3,4}</code>	<code>\momentumvectorbaseunits{2,3,4}</code>	<code>\vectormomentumbaseunits{2,3,4}</code>	<code>\momentumvectorderivedunits{2,3,4}</code>	<code>\vectormomentumderivedunits{2,3,4}</code>	<code>\momentumvectoralternateunits{2,3,4}</code>	<code>\vectormomentumalternateunits{2,3,4}</code>	<code>\momentumvectoronlybaseunits</code>	<code>\vectormomentumonlybaseunits</code>	<code>\momentumvectoronlyderivedunits</code>	<code>\vectormomentumonlyderivedunits</code>	<code>\momentumvectoronlyalternateunits</code>	<code>\vectormomentumonlyalternateunits</code>
<code>\momentum{5}</code>	<code>\momentumvalue{5}</code>	<code>\momentumbaseunits{5}</code>	<code>\momentumderivedunits{5}</code>	<code>\momentumalternateunits{5}</code>	<code>\momentumvector{2,3,4}</code>	<code>\vectormomentum{2,3,4}</code>	<code>\momentum{\mivector{2,3,4}}</code>	<code>\momentumonlybaseunits</code>	<code>\momentumonlyderivedunits</code>	<code>\momentumonlyalternateunits</code>	<code>\momentumvectorvalue{2,3,4}</code>	<code>\vectormomentumvalue{2,3,4}</code>	<code>\momentumvectorbaseunits{2,3,4}</code>	<code>\vectormomentumbaseunits{2,3,4}</code>	<code>\momentumvectorderivedunits{2,3,4}</code>	<code>\vectormomentumderivedunits{2,3,4}</code>	<code>\momentumvectoralternateunits{2,3,4}</code>	<code>\vectormomentumalternateunits{2,3,4}</code>	<code>\momentumvectoronlybaseunits</code>	<code>\vectormomentumonlybaseunits</code>	<code>\momentumvectoronlyderivedunits</code>	<code>\vectormomentumonlyderivedunits</code>	<code>\momentumvectoronlyalternateunits</code>	<code>\vectormomentumonlyalternateunits</code>
$5 \text{ kg} \cdot \text{m/s}$	$5$	$5 \text{ kg} \cdot \text{m} \cdot \text{s}^{-1}$	$5 \text{ kg} \cdot \text{m/s}$	$5 \text{ kg} \cdot \text{m/s}$	$\langle 2, 3, 4 \rangle \text{ kg} \cdot \text{m/s}$	$\langle 2, 3, 4 \rangle \text{ kg} \cdot \text{m/s}$	$\text{kg} \cdot \text{m} \cdot \text{s}^{-1}$	$\text{kg} \cdot \text{m/s}$	$\text{kg} \cdot \text{m/s}$	$\langle 2, 3, 4 \rangle$	$\langle 2, 3, 4 \rangle$	$\langle 2, 3, 4 \rangle \text{ kg} \cdot \text{m} \cdot \text{s}^{-1}$	$\langle 2, 3, 4 \rangle \text{ kg} \cdot \text{m} \cdot \text{s}^{-1}$	$\langle 2, 3, 4 \rangle \text{ kg} \cdot \text{m/s}$	$\langle 2, 3, 4 \rangle \text{ kg} \cdot \text{m/s}$	$\langle 2, 3, 4 \rangle \text{ kg} \cdot \text{m/s}$	$\langle 2, 3, 4 \rangle \text{ kg} \cdot \text{m/s}$	$\langle 2, 3, 4 \rangle \text{ kg} \cdot \text{m/s}$	$\text{kg} \cdot \text{m} \cdot \text{s}^{-1}$	$\text{kg} \cdot \text{m} \cdot \text{s}^{-1}$	$\text{kg} \cdot \text{m/s}$	$\text{kg} \cdot \text{m/s}$	$\text{kg} \cdot \text{m/s}$	$\text{kg} \cdot \text{m/s}$

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.

#### 4.4.2 Checking Physical Quantities

U 2021-12-05

**\checkquantity**{ $\langle name \rangle$ }

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

#### 4.4.3 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.34</sup> instead.

N 2021-02-24

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

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

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

<b>command</b>	<b>\acceleration</b>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
$\text{m} \cdot \text{s}^{-2}$	N/kg	$\text{m}/\text{s}^2$

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

<b>command</b>	<b>\amount</b>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
mol	mol	mol

N 2021-02-24

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

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

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

<b>command</b>	<b>\angularacceleration</b>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
$\text{rad} \cdot \text{s}^{-2}$	$\text{rad}/\text{s}^2$	$\text{rad}/\text{s}^2$

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

<b>command</b>	<b>\angularfrequency</b>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
$\text{rad} \cdot \text{s}^{-1}$	rad/s	rad/s

N 2021-02-24

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

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

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

<b>command</b>	<b>\angularimpulse</b>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
$\text{kg} \cdot \text{m}^2 \cdot \text{s}^{-1}$	$\text{kg} \cdot \text{m}^2/\text{s}$	$\text{kg} \cdot \text{m}^2/\text{s}$

N 2021-02-24

`\angularmomentum{⟨magnitude⟩}`  
`\angularmomentumvector{⟨c1, ..., cn⟩}`  
`\vectorangularmomentum{⟨c1, ..., cn⟩}`

<b>command</b>	<code>\angularmomentum</code>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
$\text{kg} \cdot \text{m}^2 \cdot \text{s}^{-1}$	$\text{kg} \cdot \text{m}^2/\text{s}$	$\text{kg} \cdot \text{m}^2/\text{s}$

N 2021-02-24

`\angularvelocity{⟨magnitude⟩}`  
`\angularvelocityvector{⟨c1, ..., cn⟩}`  
`\vectorangularvelocity{⟨c1, ..., cn⟩}`

<b>command</b>	<code>\angularvelocity</code>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
$\text{rad} \cdot \text{s}^{-1}$	$\text{rad}/\text{s}$	$\text{rad}/\text{s}$

`\area{⟨magnitude⟩}`

<b>command</b>	<code>\area</code>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
$\text{m}^2$	$\text{m}^2$	$\text{m}^2$

`\areachargedensity{⟨magnitude⟩}`

<b>command</b>	<code>\areachargedensity</code>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
$\text{A} \cdot \text{s} \cdot \text{m}^{-2}$	$\text{C}/\text{m}^2$	$\text{C}/\text{m}^2$

`\areamassdensity{⟨magnitude⟩}`

<b>command</b>	<code>\areamassdensity</code>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
$\text{kg} \cdot \text{m}^{-2}$	$\text{kg}/\text{m}^2$	$\text{kg}/\text{m}^2$

`\capacitance{⟨magnitude⟩}`

<b>command</b>	<code>\capacitance</code>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
$\text{A}^2 \cdot \text{s}^4 \cdot \text{kg}^{-1} \cdot \text{m}^{-2}$	$\text{F}$	$\text{C}/\text{V}$

`\charge{⟨magnitude⟩}`

<b>command</b>	<code>\charge</code>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
$\text{A} \cdot \text{s}$	$\text{C}$	$\text{C}$

**\cmagneticfield**{*magnitude*}**\cmagneticfieldvector**{ $\langle c_1, \dots, c_n \rangle$ }**\vectorcmagneticfield**{ $\langle c_1, \dots, c_n \rangle$ }**command****base** $\text{kg} \cdot \text{m} \cdot \text{A}^{-1} \cdot \text{s}^{-3}$ **\cmagneticfield****derived**

N/C

**alternate**

N/C

**\conductance**{*magnitude*}**command****base** $\text{A}^2 \cdot \text{s}^3 \cdot \text{kg}^{-1} \cdot \text{m}^{-2}$ **\conductance****derived**

S

**alternate**

A/V

**\conductivity**{*magnitude*}**command****base** $\text{A}^2 \cdot \text{s}^3 \cdot \text{kg}^{-1} \cdot \text{m}^{-3}$ **\conductivity****derived**

S/m

**alternate**

A/V · m

**\conventionalcurrent**{*magnitude*}**command****base**

A

**\conventionalcurrent****derived**

C/s

**alternate**

A

**\current**{*magnitude*}**command****base**

A

**\current****derived**

A

**alternate**

A

**\currentdensity**{*magnitude*}**\currentdensityvector**{ $\langle c_1, \dots, c_n \rangle$ }**\vectorcurrentdensity**{ $\langle c_1, \dots, c_n \rangle$ }**command****base** $\text{A} \cdot \text{m}^{-2}$ **\currentdensity****derived**C/s · m<sup>2</sup>**alternate**A/m<sup>2</sup>**\dielectricconstant**{*magnitude*}**command****base****\dielectricconstant****derived****alternate**

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`\direction{\langle magnitude \rangle}`  
`\directionvector{\langle c_1, \dots, c_n \rangle}`  
`\vectordirection{\langle c_1, \dots, c_n \rangle}`

<b>command</b>	<code>\direction</code>	
<b>base</b>	<b>derived</b>	<b>alternate</b>

N 2021-02-24

`\displacement{\langle magnitude \rangle}`  
`\displacementvector{\langle c_1, \dots, c_n \rangle}`  
`\vectordisplacement{\langle c_1, \dots, c_n \rangle}`

<b>command</b>	<code>\displacement</code>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
m	m	m

`\duration{\langle magnitude \rangle}`

<b>command</b>	<code>\duration</code>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
s	s	s

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`\electricdipolemoment{\langle magnitude \rangle}`  
`\electricdipolemomentvector{\langle c_1, \dots, c_n \rangle}`  
`\vectorelectricdipolemoment{\langle c_1, \dots, c_n \rangle}`

<b>command</b>	<code>\electricdipolemoment</code>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
A · s · m	C · m	C · m

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`\electricfield{\langle magnitude \rangle}`  
`\electricfieldvector{\langle c_1, \dots, c_n \rangle}`  
`\vectorelectricfield{\langle c_1, \dots, c_n \rangle}`

<b>command</b>	<code>\electricfield</code>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
kg · m · A <sup>-1</sup> · s <sup>-3</sup>	V/m	N/C

`\electricflux{\langle magnitude \rangle}`

<b>command</b>	<code>\electricflux</code>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
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}`

<b>command</b>	<code>\electricpotential</code>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
$\text{kg} \cdot \text{m}^2 \cdot \text{A}^{-1} \cdot \text{s}^{-3}$	V	V

N 2021-05-01

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

<b>command</b>	<code>\electricpotentialdifference</code>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
$\text{kg} \cdot \text{m}^2 \cdot \text{A}^{-1} \cdot \text{s}^{-3}$	V	V

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

<b>command</b>	<code>\electroncurrent</code>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
$\text{s}^{-1}$	e/s	e/s

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

<b>command</b>	<code>\emf</code>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
$\text{kg} \cdot \text{m}^2 \cdot \text{A}^{-1} \cdot \text{s}^{-3}$	V	V

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

<b>command</b>	<code>\energy</code>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
$\text{kg} \cdot \text{m}^2 \cdot \text{s}^{-2}$	J	J

N 2021-04-15

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

<b>command</b>	<code>\energyinev</code>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
eV	eV	eV

N 2021-04-15

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

<b>command</b>	<code>\energyinkev</code>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
keV	keV	keV

N 2021-04-15

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

<b>command</b>	<code>\energyinmev</code>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
MeV	MeV	MeV

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

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

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

<b>command</b>	<b>\energyflux</b>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
$\text{kg} \cdot \text{s}^{-3}$	$\text{W}/\text{m}^2$	$\text{W}/\text{m}^2$

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

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

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

<b>command</b>	<b>\force</b>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
$\text{kg} \cdot \text{m} \cdot \text{s}^{-2}$	$\text{N}$	$\text{N}$

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

<b>command</b>	<b>\frequency</b>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
$\text{s}^{-1}$	$\text{Hz}$	$\text{Hz}$

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

<b>command</b>	<b>\gravitationalfield</b>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
$\text{m} \cdot \text{s}^{-2}$	$\text{N}/\text{kg}$	$\text{N}/\text{kg}$

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

<b>command</b>	<b>\gravitationalpotential</b>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
$\text{m}^2 \cdot \text{s}^{-2}$	$\text{J}/\text{kg}$	$\text{J}/\text{kg}$

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

<b>command</b>	<code>\gravitationalpotentialdifference</code>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
$\text{m}^2 \cdot \text{s}^{-2}$	J/kg	J/kg

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

<b>command</b>	<code>\impulse</code>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
$\text{kg} \cdot \text{m} \cdot \text{s}^{-1}$	$\text{N} \cdot \text{s}$	$\text{N} \cdot \text{s}$

`\indexofrefraction{\langle magnitude \rangle}`

<b>command</b>	<code>\indexofrefraction</code>	
<b>base</b>	<b>derived</b>	<b>alternate</b>

`\inductance{\langle magnitude \rangle}`

<b>command</b>	<code>\inductance</code>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
$\text{kg} \cdot \text{m}^2 \cdot \text{A}^{-2} \cdot \text{s}^{-2}$	H	$\text{V} \cdot \text{s}/\text{A}$

`\linearchargedensity{\langle magnitude \rangle}`

<b>command</b>	<code>\linearchargedensity</code>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
$\text{A} \cdot \text{s} \cdot \text{m}^{-1}$	C/m	C/m

`\linearmassdensity{\langle magnitude \rangle}`

<b>command</b>	<code>\linearmassdensity</code>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
$\text{kg} \cdot \text{m}^{-1}$	kg/m	kg/m

`\lorentzfactor{\langle magnitude \rangle}`

<b>command</b>	<code>\lorentzfactor</code>	
<b>base</b>	<b>derived</b>	<b>alternate</b>

`\luminousintensity{\langle magnitude \rangle}`

<b>command</b>	<code>\luminousintensity</code>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
cd	cd	cd



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

<b>command</b>	<b>\magneticcharge</b>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
A · m	A · m	A · m

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

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

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

<b>command</b>	<b>\magneticdipolemoment</b>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
A · m <sup>2</sup>	A · m <sup>2</sup>	J/T

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

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

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

<b>command</b>	<b>\magneticfield</b>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
kg · A <sup>-1</sup> · s <sup>-2</sup>	N/A · m	T

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

<b>command</b>	<b>\magneticflux</b>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
kg · m <sup>2</sup> · A <sup>-1</sup> · s <sup>-2</sup>	T · m <sup>2</sup>	V · s

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

<b>command</b>	<b>\mass</b>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
kg	kg	kg

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

<b>command</b>	<b>\mobility</b>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
kg · m <sup>2</sup> · A <sup>-1</sup> · s <sup>-4</sup>	m <sup>2</sup> /V · s	C · m/N · s

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

<b>command</b>	<b>\momentofinertia</b>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
kg · m <sup>2</sup>	J · s <sup>2</sup>	kg · m <sup>2</sup>

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

<b>command</b>	<b>\momentum</b>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
$\text{kg} \cdot \text{m} \cdot \text{s}^{-1}$	$\text{kg} \cdot \text{m}/\text{s}$	$\text{kg} \cdot \text{m}/\text{s}$

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

<b>command</b>	<b>\momentumflux</b>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
$\text{kg} \cdot \text{m}^{-1} \cdot \text{s}^{-2}$	$\text{N}/\text{m}^2$	$\text{N}/\text{m}^2$

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

<b>command</b>	<b>\numberdensity</b>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
$\text{m}^{-3}$	$/\text{m}^3$	$/\text{m}^3$

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

<b>command</b>	<b>\permeability</b>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
$\text{kg} \cdot \text{m} \cdot \text{A}^{-2} \cdot \text{s}^{-2}$	$\text{H}/\text{m}$	$\text{T} \cdot \text{m}/\text{A}$

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

<b>command</b>	<b>\permittivity</b>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
$\text{A}^2 \cdot \text{s}^4 \cdot \text{kg}^{-1} \cdot \text{m}^{-3}$	$\text{F}/\text{m}$	$\text{C}^2/\text{N} \cdot \text{m}^2$

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

<b>command</b>	<b>\planeangle</b>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
$\text{m} \cdot \text{m}^{-1}$	$\text{rad}$	$\text{rad}$

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

<b>command</b>	<b>\polarizability</b>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
$\text{A}^2 \cdot \text{s}^4 \cdot \text{kg}^{-1}$	$\text{C} \cdot \text{m}^2/\text{V}$	$\text{C}^2 \cdot \text{m}/\text{N}$

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

<b>command</b>	<code>\power</code>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
$\text{kg} \cdot \text{m}^2 \cdot \text{s}^{-3}$	W	J/s

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

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

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

<b>command</b>	<code>\poynting</code>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
$\text{kg} \cdot \text{s}^{-3}$	$\text{W}/\text{m}^2$	$\text{W}/\text{m}^2$

`\pressure`{ $\langle magnitude \rangle$ }

<b>command</b>	<code>\pressure</code>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
$\text{kg} \cdot \text{m}^{-1} \cdot \text{s}^{-2}$	Pa	$\text{N}/\text{m}^2$

`\relativepermeability`{ $\langle magnitude \rangle$ }

<b>command</b>	<code>\relativepermeability</code>	
<b>base</b>	<b>derived</b>	<b>alternate</b>

`\relativepermittivity`{ $\langle magnitude \rangle$ }

<b>command</b>	<code>\relativepermittivity</code>	
<b>base</b>	<b>derived</b>	<b>alternate</b>

`\resistance`{ $\langle magnitude \rangle$ }

<b>command</b>	<code>\resistance</code>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
$\text{kg} \cdot \text{m}^2 \cdot \text{A}^{-2} \cdot \text{s}^{-3}$	$\Omega$	$\Omega$

`\resistivity`{ $\langle magnitude \rangle$ }

<b>command</b>	<code>\resistivity</code>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
$\text{kg} \cdot \text{m}^3 \cdot \text{A}^{-2} \cdot \text{s}^{-3}$	$\Omega \cdot \text{m}$	$\text{V} \cdot \text{m}/\text{A}$

`\solidangle`{ $\langle magnitude \rangle$ }

<b>command</b>	<code>\solidangle</code>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
$\text{m}^2 \cdot \text{m}^{-2}$	sr	sr

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

<b>command</b>	<b>\specificheatcapacity</b>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
$\text{m}^2 \cdot \text{s}^{-2} \cdot \text{K}^{-1}$	$\text{J/K} \cdot \text{kg}$	$\text{J/K} \cdot \text{kg}$

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

<b>command</b>	<b>\springstiffness</b>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
$\text{kg} \cdot \text{s}^{-2}$	$\text{N/m}$	$\text{N/m}$

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

<b>command</b>	<b>\springstretch</b>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
$\text{m}$	$\text{m}$	$\text{m}$

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

<b>command</b>	<b>\stress</b>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
$\text{kg} \cdot \text{m}^{-1} \cdot \text{s}^{-2}$	$\text{Pa}$	$\text{N/m}^2$

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

<b>command</b>	<b>\strain</b>	
<b>base</b>	<b>derived</b>	<b>alternate</b>

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

<b>command</b>	<b>\temperature</b>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
$\text{K}$	$\text{K}$	$\text{K}$

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

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

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

<b>command</b>	<b>\torque</b>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
$\text{kg} \cdot \text{m}^2 \cdot \text{s}^{-2}$	$\text{N} \cdot \text{m}$	$\text{N} \cdot \text{m}$

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

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

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

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<b>command</b>	<b>\velocity</b>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
$\text{m} \cdot \text{s}^{-1}$	$\text{m/s}$	$\text{m/s}$

**\velocity** $\{\langle magnitude \rangle\}$   
**\velocitycvector** $\{\langle c_1, \dots, c_n \rangle\}$   
**\vectorvelocityc** $\{\langle c_1, \dots, c_n \rangle\}$

<b>command</b>	<b>\velocityc</b>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
$\text{c}$	$\text{c}$	$\text{c}$

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

<b>command</b>	<b>\volume</b>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
$\text{m}^3$	$\text{m}^3$	$\text{m}^3$

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

<b>command</b>	<b>\volumechargedensity</b>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
$\text{A} \cdot \text{s}/\text{m}^{-3}$	$\text{C}/\text{m}^3$	$\text{C}/\text{m}^3$

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

<b>command</b>	<b>\volumemassdensity</b>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
$\text{kg} \cdot \text{m}^{-3}$	$\text{kg}/\text{m}^3$	$\text{kg}/\text{m}^3$

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

<b>command</b>	<b>\wavelength</b>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
$\text{m}$	$\text{m}$	$\text{m}$

**\wavenumber** $\{\langle magnitude \rangle\}$   
**\wavenumbervector** $\{\langle c_1, \dots, c_n \rangle\}$   
**\vectorwavenumber** $\{\langle c_1, \dots, c_n \rangle\}$

<b>command</b>	<b>\wavenumber</b>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
$\text{m}^{-1}$	$/\text{m}$	$/\text{m}$

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

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<b>command</b>	<b>\work</b>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
$\text{kg} \cdot \text{m}^2 \cdot \text{s}^{-2}$	J	J

**\youngsm modulus**{*<magnitude>*}

<b>command</b>	<b>\youngsm modulus</b>	
<b>base</b>	<b>derived</b>	<b>alternate</b>
$\text{kg} \cdot \text{m}^{-1} \cdot \text{s}^{-2}$	Pa	N/m <sup>2</sup>

#### 4.4.4 Defining and Redefining Physical Quantities

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N 2021-02-21

**\newsclarquantity**{*<name>*}{*<base units>*}[*<derived units>*][*<alternate units>*]  
**\renewsclarquantity**{*<name>*}{*<base units>*}[*<derived units>*][*<alternate units>*]

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

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**\newvectorquantity**{*<name>*}{*<base units>*}[*<derived units>*][*<alternate units>*]  
**\renewvectorquantity**{*<name>*}{*<base units>*}[*<derived units>*][*<alternate units>*]

Command to (re)define a new/existing vector quantity. If the derived or alternate units are omitted, they are defined to be the same as the base units. Do not use both this command and **\newsclarquantity** or **\renewsclarquantity** to (re)define a quantity.

#### 4.4.5 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.23</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.

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**\alwaysusebaseunits**  
**\alwaysusederivedunits**  
**\alwaysusealternateunits**

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

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**\hereusebaseunits**{*<content>*}  
**\hereusederivedunits**{*<content>*}  
**\hereusedalternateunits**{*<content>*}

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

<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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`\begin{usederivedunits}` (use derived units)  
`\(environment content\)`

U 2021-02-26

`\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>		$9 \times 10^9 \text{ m/F}$
<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>\)</code>	
<code>\end{usealternateunits}</code>		

## 4.5 Physical Constants

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

### 4.5.2 Checking Physical Constants

U 2021-12-05

`\checkconstant{ $\langle name \rangle$ }`

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

### 4.5.3 Predefined Physical Constants

Every other defined physical constant can be treated similarly to `\oofpez`<sup>P.27</sup>. 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.25</sup> and `\biotsavartconstant` are defined as semantic aliases for, respectively, `\oofpez`<sup>P.27</sup> and `\mzofp`<sup>P.27</sup>.

`\avogadro` (exact)

<b>command</b>	<code>\avogadro</code>	
<b>symbol</b>	<b>approximate</b>	<b>precise</b>
N <sub>A</sub>	$6 \times 10^{23}$	$6.02214076 \times 10^{23}$
<b>base</b>	<b>derived</b>	<b>alternate</b>
mol <sup>-1</sup>	/mol	/mol

N 2021-02-02

\biotsavartconstant

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

\bohrradius



<b>command</b>	<code>\bohrradius</code>	
<b>symbol</b>	<b>approximate</b>	<b>precise</b>
$a_o$	$5.3 \times 10^{-11}$	$5.29177210903 \times 10^{-11}$
<b>base</b>	<b>derived</b>	<b>alternate</b>
m	m	m

`\boltzmann` (exact)

<b>command</b>	<code>\boltzmann</code>	
<b>symbol</b>	<b>approximate</b>	<b>precise</b>
$k_B$	$1.4 \times 10^{-23}$	$1.380649 \times 10^{-23}$
<b>base</b>	<b>derived</b>	<b>alternate</b>
$\text{kg} \cdot \text{m}^2 \cdot \text{s}^{-2} \cdot \text{K}^{-1}$	J/K	J/K

N 2021-02-02

`\coulombconstant`

<b>command</b>	<code>\coulombconstant</code>	
<b>symbol</b>	<b>approximate</b>	<b>precise</b>
$\frac{1}{4\pi\epsilon_o}$	$9 \times 10^9$	$8.9875517923 \times 10^9$
<b>base</b>	<b>derived</b>	<b>alternate</b>
$\text{kg} \cdot \text{m}^3 \cdot \text{A}^{-2} \cdot \text{s}^{-4}$	m/F	$\text{N} \cdot \text{m}^2/\text{C}^2$

`\earthmass`

<b>command</b>	<code>\earthmass</code>	
<b>symbol</b>	<b>approximate</b>	<b>precise</b>
$M_{\text{Earth}}$	$6.0 \times 10^{24}$	$5.9722 \times 10^{24}$
<b>base</b>	<b>derived</b>	<b>alternate</b>
kg	kg	kg

`\earthmoondistance`

<b>command</b>	<code>\earthmoondistance</code>	
<b>symbol</b>	<b>approximate</b>	<b>precise</b>
$d_{\text{EM}}$	$3.8 \times 10^8$	$3.81550 \times 10^8$
<b>base</b>	<b>derived</b>	<b>alternate</b>
m	m	m

`\earthradius`

<b>command</b>	<code>\earthradius</code>	
<b>symbol</b>	<b>approximate</b>	<b>precise</b>
$R_{\text{Earth}}$	$6.4 \times 10^6$	$6.3781 \times 10^6$
<b>base</b>	<b>derived</b>	<b>alternate</b>
m	m	m

`\earthsundistance`

<b>command</b>	<code>\earthsundistance</code>	
<b>symbol</b>	<b>approximate</b>	<b>precise</b>
$d_{\text{ES}}$	$1.5 \times 10^{11}$	$1.496 \times 10^{11}$
<b>base</b>	<b>derived</b>	<b>alternate</b>
m	m	m

#### `\electroncharge`

<b>command</b>	<code>\electroncharge</code>	
<b>symbol</b>	<b>approximate</b>	<b>precise</b>
$q_e$	$-1.6 \times 10^{-19}$	$-1.602176634 \times 10^{-19}$
<b>base</b>	<b>derived</b>	<b>alternate</b>
A · s	C	C

#### `\electronCharge`

<b>command</b>	<code>\electronCharge</code>	
<b>symbol</b>	<b>approximate</b>	<b>precise</b>
$Q_e$	$-1.6 \times 10^{-19}$	$-1.602176634 \times 10^{-19}$
<b>base</b>	<b>derived</b>	<b>alternate</b>
A · s	C	C

#### `\electronmass`

<b>command</b>	<code>\electronmass</code>	
<b>symbol</b>	<b>approximate</b>	<b>precise</b>
$m_e$	$9.1 \times 10^{-31}$	$9.1093837015 \times 10^{-31}$
<b>base</b>	<b>derived</b>	<b>alternate</b>
kg	kg	kg

#### `\elementarycharge` (exact)

<b>command</b>	<code>\elementarycharge</code>	
<b>symbol</b>	<b>approximate</b>	<b>precise</b>
e	$1.6 \times 10^{-19}$	$1.602176634 \times 10^{-19}$
<b>base</b>	<b>derived</b>	<b>alternate</b>
A · s	C	C

#### `\finestructure`

<b>command</b>	<code>\finestructure</code>	
<b>symbol</b>	<b>approximate</b>	<b>precise</b>
$\alpha$	$\frac{1}{137}$	$7.2973525693 \times 10^{-3}$
<b>base</b>	<b>derived</b>	<b>alternate</b>

#### `\hydrogenmass`

<b>command</b>	<code>\hydrogenmass</code>	
<b>symbol</b>	<b>approximate</b>	<b>precise</b>
$m_{\text{H}}$	$1.7 \times 10^{-27}$	$1.6737236 \times 10^{-27}$
<b>base</b>	<b>derived</b>	<b>alternate</b>
kg	kg	kg

#### `\moonearthdistance`

<b>command</b>	<code>\moonearthdistance</code>	
<b>symbol</b>	<b>approximate</b>	<b>precise</b>
$d_{\text{ME}}$	$3.8 \times 10^8$	$3.81550 \times 10^8$
<b>base</b>	<b>derived</b>	<b>alternate</b>
m	m	m

#### `\moonmass`

<b>command</b>	<code>\moonmass</code>	
<b>symbol</b>	<b>approximate</b>	<b>precise</b>
$M_{\text{Moon}}$	$7.3 \times 10^{22}$	$7.342 \times 10^{22}$
<b>base</b>	<b>derived</b>	<b>alternate</b>
kg	kg	kg

#### `\moonradius`

<b>command</b>	<code>\moonradius</code>	
<b>symbol</b>	<b>approximate</b>	<b>precise</b>
$R_{\text{Moon}}$	$1.7 \times 10^6$	$1.7371 \times 10^6$
<b>base</b>	<b>derived</b>	<b>alternate</b>
m	m	m

#### `\mzofp`

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

#### `\neutronmass`

<b>command</b>	<code>\neutronmass</code>	
<b>symbol</b>	<b>approximate</b>	<b>precise</b>
$m_{\text{n}}$	$1.7 \times 10^{-27}$	$1.67492749804 \times 10^{-27}$
<b>base</b>	<b>derived</b>	<b>alternate</b>
kg	kg	kg

#### `\oofpez`

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

#### \oofpezcs

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

#### \planck (exact)

<b>command</b>	<b>\planck</b>	<b>precise</b>
<b>symbol</b>	<b>approximate</b>	
$h$	$6.6 \times 10^{-34}$	$6.62607015 \times 10^{-34}$
<b>base</b>	<b>derived</b>	<b>alternate</b>
$\text{kg} \cdot \text{m}^2 \cdot \text{s}^{-1}$	$\text{J} \cdot \text{s}$	$\text{J} \cdot \text{s}$

#### \planckbar

<b>command</b>	<b>\planckbar</b>	<b>precise</b>
<b>symbol</b>	<b>approximate</b>	
$\hbar$	$1.1 \times 10^{-34}$	$1.054571817 \times 10^{-34}$
<b>base</b>	<b>derived</b>	<b>alternate</b>
$\text{kg} \cdot \text{m}^2 \cdot \text{s}^{-1}$	$\text{J} \cdot \text{s}$	$\text{J} \cdot \text{s}$

#### \planckc

<b>command</b>	<b>\planckc</b>	<b>precise</b>
<b>symbol</b>	<b>approximate</b>	
$hc$	$2.0 \times 10^{-25}$	$1.98644586 \times 10^{-25}$
<b>base</b>	<b>derived</b>	<b>alternate</b>
$\text{kg} \cdot \text{m}^3 \cdot \text{s}^{-2}$	$\text{J} \cdot \text{m}$	$\text{J} \cdot \text{m}$

#### \protoncharge

<b>command</b>	<b>\protoncharge</b>	<b>precise</b>
<b>symbol</b>	<b>approximate</b>	
$q_p$	$+1.6 \times 10^{-19}$	$+1.602176634 \times 10^{-19}$
<b>base</b>	<b>derived</b>	<b>alternate</b>
$\text{A} \cdot \text{s}$	$\text{C}$	$\text{C}$

#### \protonCharge

<b>command</b>	<code>\protonCharge</code>	
<b>symbol</b>	<b>approximate</b>	<b>precise</b>
$Q_p$	$+1.6 \times 10^{-19}$	$+1.602176634 \times 10^{-19}$
<b>base</b>	<b>derived</b>	<b>alternate</b>
A · s	C	C

#### `\protonmass`

<b>command</b>	<code>\protonmass</code>	
<b>symbol</b>	<b>approximate</b>	<b>precise</b>
$m_p$	$1.7 \times 10^{-27}$	$1.672621898 \times 10^{-27}$
<b>base</b>	<b>derived</b>	<b>alternate</b>
kg	kg	kg

#### `\rydberg`

<b>command</b>	<code>\rydberg</code>	
<b>symbol</b>	<b>approximate</b>	<b>precise</b>
$R_\infty$	$1.1 \times 10^7$	$1.0973731568160 \times 10^7$
<b>base</b>	<b>derived</b>	<b>alternate</b>
$m^{-1}$	$m^{-1}$	$m^{-1}$

#### `\speedoflight` (exact)

<b>command</b>	<code>\speedoflight</code>	
<b>symbol</b>	<b>approximate</b>	<b>precise</b>
$c$	$3 \times 10^8$	$2.99792458 \times 10^8$
<b>base</b>	<b>derived</b>	<b>alternate</b>
$m \cdot s^{-1}$	m/s	m/s

#### `\stefanboltzmann`

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

#### `\sunearthdistance`

<b>command</b>	<code>\sunearthdistance</code>	
<b>symbol</b>	<b>approximate</b>	<b>precise</b>
$d_{SE}$	$1.5 \times 10^{11}$	$1.496 \times 10^{11}$
<b>base</b>	<b>derived</b>	<b>alternate</b>
m	m	m

#### `\sunradius`

<b>command</b>	<code>\sunradius</code>	
<b>symbol</b>	<b>approximate</b>	<b>precise</b>
$R_{\text{Sun}}$	$7.0 \times 10^8$	$6.957 \times 10^8$
<b>base</b>	<b>derived</b>	<b>alternate</b>
m	m	m

#### `\surfacegravfield`

<b>command</b>	<code>\surfacegravfield</code>	
<b>symbol</b>	<b>approximate</b>	<b>precise</b>
$g$	9.8	9.807
<b>base</b>	<b>derived</b>	<b>alternate</b>
$\text{m} \cdot \text{s}^{-2}$	N/kg	N/kg

#### `\universalgrav`

<b>command</b>	<code>\universalgrav</code>	
<b>symbol</b>	<b>approximate</b>	<b>precise</b>
$G$	$6.7 \times 10^{-11}$	$6.67430 \times 10^{-11}$
<b>base</b>	<b>derived</b>	<b>alternate</b>
$\text{m}^3 \cdot \text{kg}^{-1} \cdot \text{s}^{-2}$	$\text{N} \cdot \text{m}^2/\text{kg}^2$	$\text{N} \cdot \text{m}^2/\text{kg}^2$

#### `\vacuumpermeability`

<b>command</b>	<code>\vacuumpermeability</code>	
<b>symbol</b>	<b>approximate</b>	<b>precise</b>
$\mu_0$	$4\pi \times 10^{-7}$	$4\pi \times 10^{-7}$
<b>base</b>	<b>derived</b>	<b>alternate</b>
$\text{kg} \cdot \text{m} \cdot \text{A}^{-2} \cdot \text{s}^{-2}$	H/m	$\text{T} \cdot \text{m}/\text{A}$

#### `\vacuumpermittivity`

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

### 4.5.4 Defining and Redefining Physical Constants

N 2021-02-16

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

N 2021-02-21

**`\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.

### 4.5.5 Changing Precision

[Changing units](#)<sup>→ P.22</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{<content>}`  
`\hereusepreciseconstants{<content>}`

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)  
`<environment content>`  
`\end{useapproximateconstants}`  
`\begin{usepreciseconstants}` (use precise constants)  
`<environment content>`  
`\end{usepreciseconstants}`

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

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

## 4.6 Predefined Units and Constructs

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

`\per`  
`\usk`  
`\unit{<magnitude>}{<unit>}`  
`\emptyunit`  
`\ampere`  
`\atomicmassunit`  
`\candela`

	<code>\coulomb</code>	
	<code>\degree</code>	
	<code>\electronvolt</code>	(not SI but common in introductory physics)
<code>N 2021-04-15</code>	<code>\ev</code>	(alias)
	<code>\farad</code>	
	<code>\henry</code>	
	<code>\hertz</code>	
	<code>\joule</code>	
	<code>\kelvin</code>	
<code>N 2021-04-15</code>	<code>\kev</code>	(alias)
<code>N 2021-04-15</code>	<code>\kiloelectronvolt</code>	(not SI but common in introductory physics)
	<code>\kilogram</code>	
	<code>\lightspeed</code>	(not SI but common relativity)
<code>N 2021-04-15</code>	<code>\megaelectronvolt</code>	(not SI but common in introductory physics)
	<code>\meter</code>	
	<code>\metre</code>	(alias)
<code>N 2021-04-15</code>	<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
		□
<code>\( \per \)</code>	<code>\\</code>	A
<code>\( \usk \)</code>	<code>\\</code>	u
<code>\( \unit{3}{\meter\per\second} \)</code>	<code>\\</code>	cd
<code>\( \emptyunit \)</code>	<code>\\</code>	C
<code>\( \ampere \)</code>	<code>\\</code>	°
<code>\( \atomicmassunit \)</code>	<code>\\</code>	eV
<code>\( \candela \)</code>	<code>\\</code>	F
<code>\( \coulomb \)</code>	<code>\\</code>	H
<code>\( \degree \)</code>	<code>\\</code>	Hz
<code>\( \electronvolt \)</code>	<code>\\</code>	J
<code>\( \farad \)</code>	<code>\\</code>	K
<code>\( \henry \)</code>	<code>\\</code>	keV
<code>\( \hertz \)</code>	<code>\\</code>	kg
<code>\( \joule \)</code>	<code>\\</code>	c
<code>\( \kelvin \)</code>	<code>\\</code>	m
<code>\( \kev \)</code>	<code>\\</code>	m
<code>\( \kilogram \)</code>	<code>\\</code>	MeV
<code>\( \lightspeed \)</code>	<code>\\</code>	mol
<code>\( \meter \)</code>	<code>\\</code>	N
<code>\( \metre \)</code>	<code>\\</code>	Ω
<code>\( \mev \)</code>	<code>\\</code>	Pa
<code>\( \mole \)</code>	<code>\\</code>	rad
<code>\( \newton \)</code>	<code>\\</code>	s
<code>\( \ohm \)</code>	<code>\\</code>	S
<code>\( \pascal \)</code>	<code>\\</code>	sr
<code>\( \radian \)</code>	<code>\\</code>	T
<code>\( \second \)</code>	<code>\\</code>	V
<code>\( \siemens \)</code>	<code>\\</code>	W
<code>\( \steradian \)</code>	<code>\\</code>	Wb
<code>\( \tesla \)</code>	<code>\\</code>	□ <sup>2</sup>
<code>\( \volt \)</code>	<code>\\</code>	□ <sup>3</sup>
<code>\( \watt \)</code>	<code>\\</code>	□ <sup>4</sup>
<code>\( \weber \)</code>	<code>\\</code>	□ <sup>-1</sup>
<code>\( \emptyunit\tothetwo \)</code>	<code>\\</code>	□ <sup>-2</sup>
<code>\( \emptyunit\tothethree \)</code>	<code>\\</code>	□ <sup>-3</sup>
<code>\( \emptyunit\tothefour \)</code>	<code>\\</code>	□ <sup>-4</sup>
<code>\( \emptyunit\inverse \)</code>	<code>\\</code>	
<code>\( \emptyunit\totheinversetwo \)</code>	<code>\\</code>	
<code>\( \emptyunit\totheinversethree \)</code>	<code>\\</code>	
<code>\( \emptyunit\totheinversefour \)</code>	<code>\\</code>	

`\( \hbar \)`

$\hbar$

`\tento{⟨number⟩}`

`\timestento{⟨number⟩}`

`\xtento{⟨number⟩}`

Commands for powers of ten and scientific notation.

`\( \tento{-4} \)` `\`

$10^{-4}$

`\( 3\timestento{8} \)` `\`

$3 \times 10^8$

`\( 3\xtento{8} \)`

$3 \times 10^8$

U 2021-12-05

`\mivector[⟨delimiter⟩]{⟨c1, ..., cn⟩}[⟨units⟩]`

Typesets a vector as either numeric or symbolic components with an optional unit (for numerical components only). There must be more than one component, and 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*.

`\( \mivector{p_0,p_1,p_2,p_3} \)`

`\`

$\langle p_0, p_1, p_2, p_3 \rangle$

`\( \mivector{\gamma mc, \gamma mv_x, \gamma mv_y, \gamma mv_z} \)` `\`

`\`

$\langle \gamma mc, \gamma mv_x, \gamma mv_y, \gamma mv_z \rangle$

`\( \mivector{\frac{Q_1 Q_2}{x^2}, 0, 0} \)`

`\`

$\langle \frac{Q_1 Q_2}{x^2}, 0, 0 \rangle$

`\( \mivector{-1, 0, 0} \)`

`\`

$\langle -1, 0, 0 \rangle$

`\( \mivector{-1, 0, 0}[\text{velocityonlyderivedunits}] \)`

`\`

$\langle -1, 0, 0 \rangle \text{ m/s}$

`\( \mivector{-1, 0, 0}[\text{meter\per\second}] \)`

`\`

$\langle -1, 0, 0 \rangle \text{ m/s}$

`\( \velocity{\mivector{-1, 0, 0}} \)`

`\`

$\langle -1, 0, 0 \rangle \text{ m/s}$

## 4.7 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{3.0.2}
2 \def\mandi@date{2021-12-05}
3 \NeedsTeXFormat{LaTeX2e}[2020-02-02]
4 \DeclareRelease{v3.0.2}{2021-12-05}{mandi.sty}
5 \DeclareCurrentRelease{v\mandi@version}{\mandi@date}
6 \ProvidesPackage{mandi}
7 [\mandi@date\space v\mandi@version\space Macros for physical quantities]
```

Define a convenient package version command.

```
8 \newcommand*\mandiversion{\v\mandi@version\space dated \mandi@date}
```

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

```
9 \RequirePackage{pgfplots}           % needed for key-value interface
10 \RequirePackage{array}              % needed for \checkquantity and \checkconstant
11 \RequirePackage{iftex}              % needed for requiring LuaLaTeX
12 \RequirePackage{unicode-math}       % needed for Unicode support

13 \IfFormatAtLeastTF {2020-10-01} % load xparse if necessary
14 {}%
15 {\RequirePackage{xparse}}%
16 \RequireLuaTeX                    % require this engine
```

Parts of the unit engine have been rewritten with [xparse](#) for both clarity and power. Note that [xparse](#) is now part of the L<sup>A</sup>T<sub>E</sub>X 2<sub>ε</sub> kernel. Other parts have been rewritten in [expl](#) with a look to the future.

Generic internal selectors.

```
17 \newcommand*\mandi@selectunits{}
18 \newcommand*\mandi@selectprecision{}
```

Specific internal selectors.

```
19 \newcommand*\mandi@selectapproximate[2]{#1} % really \@firstoftwo
20 \newcommand*\mandi@selectprecise[2]{#2} % really \@secondoftwo
21 \newcommand*\mandi@selectbaseunits[3]{#1} % really \@firstofthree
22 \newcommand*\mandi@selectderivedunits[3]{#2} % really \@secondofthree
23 \newcommand*\mandi@selectalternateunits[3]{#3} % really \@thirdofthree
```

Document level global switches.

```
24 \NewDocumentCommand{\alwaysusebaseunits}{}
25 {\renewcommand*\mandi@selectunits{\mandi@selectbaseunits}}%
26 \NewDocumentCommand{\alwaysusederivedunits}{}
27 {\renewcommand*\mandi@selectunits{\mandi@selectderivedunits}}%
28 \NewDocumentCommand{\alwaysusealternateunits}{}
29 {\renewcommand*\mandi@selectunits{\mandi@selectalternateunits}}%
30 \NewDocumentCommand{\alwaysuseapproximateconstants}{}
31 {\renewcommand*\mandi@selectprecision{\mandi@selectapproximate}}%
32 \NewDocumentCommand{\alwaysusepreciseconstants}{}
33 {\renewcommand*\mandi@selectprecision{\mandi@selectprecise}}%
```

Document level localized variants.

```
34 \NewDocumentCommand{\hereusebaseunits}{ m }{\begingroup\alwaysusebaseunits#1\endgroup}%
35 \NewDocumentCommand{\hereusederivedunits}{ m }{\begingroup\alwaysusederivedunits#1\endgroup}%
36 \NewDocumentCommand{\hereusealternateunits}{ m }{\begingroup\alwaysusealternateunits#1\endgroup}%
37 \NewDocumentCommand{\hereuseapproximateconstants}{ m }{\begingroup\alwaysuseapproximateconstants#1\endgroup}%
38 \NewDocumentCommand{\hereusepreciseconstants}{ m }{\begingroup\alwaysusepreciseconstants#1\endgroup}%
```

Document level environments.

```

39 \NewDocumentEnvironment{usebaseunits}{}{\alwaysusebaseunits}{}%
40 \NewDocumentEnvironment{usederivedunits}{}{\alwaysusederivedunits}{}%
41 \NewDocumentEnvironment{usealternateunits}{}{\alwaysusealternateunits}{}%
42 \NewDocumentEnvironment{useapproximateconstants}{}{\alwaysuseapproximateconstants}{}%
43 \NewDocumentEnvironment{usepreciseconstants}{}{\alwaysusepreciseconstants}{}%

```

mandi now has a key-value interface, implemented with `pgfopts` and `pgfkeys`. There are two options: `units`<sup>P.8</sup>, with values `base`, `derived`, or `alternate` selects the default form of units `preciseconstants`<sup>P.8</sup>, 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.

```

44 \newif\ifusingpreciseconstants
45 \pgfkeys{%
46   /mandi/options/.cd,
47   initial@setup/.style={%
48     /mandi/options/buffered@units/.initial=alternate,%
49   },%
50   initial@setup,%
51   preciseconstants/.is if=usingpreciseconstants,%
52   units/.is choice,%
53   units/.default=derived,%
54   units/alternate/.style={/mandi/options/buffered@units=alternate},%
55   units/base/.style={/mandi/options/buffered@units=base},%
56   units/derived/.style={/mandi/options/buffered@units=derived},%
57   .unknown/.code={%
58     \typeout{}%
59     \typeout{mandi: You used unknown option '\pgfkeyscurrentname'.}%
60   },%
61 }%

```

Process the options.

```

62 \ProcessPgfPackageOptions{/mandi/options}

```

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

```

63 \typeout{}%
64 \typeout{mandi: You are using mandi \mandiversion.}%
65 \typeout{mandi: This package requires LuaLaTeX.}%
66 \typeout{mandi: Loadtime options...}

```

Complete the banner by showing currently selected options. The value of the `units`<sup>P.8</sup> key is used in situ to set the default units.

```

67 \newcommand*{\mandi@do@setup}{%
68   \csname alwaysuse\pgfkeysvalueof{/mandi/options/buffered@units}units\endcsname%
69   \typeout{mandi: You will get \pgfkeysvalueof{/mandi/options/buffered@units}\space units.}%
70   \ifusingpreciseconstants
71     \alwaysusepreciseconstants
72     \typeout{mandi: You will get precise constants.}%
73   \else
74     \alwaysuseapproximateconstants
75     \typeout{mandi: You will get approximate constants.}%
76   \fi
77   \typeout{}%
78 }%
79 \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.

```

80 \NewDocumentCommand{\mandisetup}{ m }%
81 {%
82   \IfValueT{#1}%
83   {%
84     \pgfqkeys{/mandi/options}{#1}
85     \typeout{}%
86     \typeout{mandi: mandisetup options...}
87     \mandi@do@setup
88   }%
89 }%

```

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 `\symp{...}` from the `unicode-math` package.

```

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

```

```

136 \ExplSyntaxOn
137 \cs_new:Npn \__mandi_newscalarquantity:nnnn #1#2#3#4
138 {
139   \cs_new:cpn {#1} ##1 {\unit{##1}{\mandi@selectunits{#2}{#3}{#4}}}
140   \cs_new:cpn {#1value} ##1 {##1}
141   \cs_new:cpn {#1baseunits} ##1 {\unit{##1}{\mandi@selectbaseunits{#2}{#3}{#4}}}
142   \cs_new:cpn {#1derivedunits} ##1 {\unit{##1}{\mandi@selectderivedunits{#2}{#3}{#4}}}
143   \cs_new:cpn {#1alternateunits} ##1 {\unit{##1}{\mandi@selectalternateunits{#2}{#3}{#4}}}
144   \cs_new:cpn {#1onlybaseunits} {\mandi@selectbaseunits{#2}{#3}{#4}}
145   \cs_new:cpn {#1onlyderivedunits} {\mandi@selectderivedunits{#2}{#3}{#4}}
146   \cs_new:cpn {#1onlyalternateunits} {\mandi@selectalternateunits{#2}{#3}{#4}}
147 }
148 \NewDocumentCommand{\newscalarquantity}{ m m O{#2} O{#2} }
149 {
150   \__mandi_newscalarquantity:nnnn { #1 }{ #2 }{ #3 }{ #4 }
151 }
152 \ExplSyntaxOff

```

Redefining an existing scalar quantity.

```

153 \ExplSyntaxOn
154 \cs_new:Npn \__mandi_renewscalarquantity:nnnn #1#2#3#4
155 {
156   \cs_set:cpn {#1} ##1 {\unit{##1}{\mandi@selectunits{#2}{#3}{#4}}}
157   \cs_set:cpn {#1value} ##1 {##1}
158   \cs_set:cpn {#1baseunits} ##1 {\unit{##1}{\mandi@selectbaseunits{#2}{#3}{#4}}}
159   \cs_set:cpn {#1derivedunits} ##1 {\unit{##1}{\mandi@selectderivedunits{#2}{#3}{#4}}}
160   \cs_set:cpn {#1alternateunits} ##1 {\unit{##1}{\mandi@selectalternateunits{#2}{#3}{#4}}}
161   \cs_set:cpn {#1onlybaseunits} {\mandi@selectbaseunits{#2}{#3}{#4}}
162   \cs_set:cpn {#1onlyderivedunits} {\mandi@selectderivedunits{#2}{#3}{#4}}
163   \cs_set:cpn {#1onlyalternateunits} {\mandi@selectalternateunits{#2}{#3}{#4}}
164 }
165 \NewDocumentCommand{\renewscalarquantity}{ m m O{#2} O{#2} }
166 {
167   \__mandi_renewscalarquantity:nnnn { #1 }{ #2 }{ #3 }{ #4 }
168 }
169 \ExplSyntaxOff

```

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

```

170 \ExplSyntaxOn
171 \cs_new:Npn \__mandi_newvectorquantity:nnnn #1#2#3#4
172 {
173   \__mandi_newscalarquantity:nnnn { #1 }{ #2 }{ #3 }{ #4 }
174   \cs_new:cpn {vector#1} ##1 {\unit{\mivector{##1}}{\mandi@selectunits{#2}{#3}{#4}}}
175   \cs_new:cpn {#1vector} ##1 {\unit{\mivector{##1}}{\mandi@selectunits{#2}{#3}{#4}}}
176   \cs_new:cpn {vector#1value} ##1 {\mivector{##1}}
177   \cs_new:cpn {#1vectorvalue} ##1 {\mivector{##1}}
178   \cs_new:cpn {vector#1baseunits} ##1 {\unit{\mivector{##1}}{\mandi@selectbaseunits{#2}{#3}{#4}}}
179   \cs_new:cpn {#1vectorbaseunits} ##1 {\unit{\mivector{##1}}{\mandi@selectbaseunits{#2}{#3}{#4}}}
180   \cs_new:cpn {vector#1derivedunits} ##1 {\unit{\mivector{##1}}{\mandi@selectderivedunits{#2}{#3}{#4}}}
181   \cs_new:cpn {#1vectorderivedunits} ##1 {\unit{\mivector{##1}}{\mandi@selectderivedunits{#2}{#3}{#4}}}
182   \cs_new:cpn {vector#1alternateunits} ##1 {\unit{\mivector{##1}}{\mandi@selectalternateunits{#2}{#3}{#4}}}
183   \cs_new:cpn {#1vectoralternateunits} ##1 {\unit{\mivector{##1}}{\mandi@selectalternateunits{#2}{#3}{#4}}}
184   \cs_new:cpn {vector#1onlybaseunits} {\mandi@selectbaseunits{#2}{#3}{#4}}
185   \cs_new:cpn {#1vectoronlybaseunits} {\mandi@selectbaseunits{#2}{#3}{#4}}
186   \cs_new:cpn {vector#1onlyderivedunits} {\mandi@selectderivedunits{#2}{#3}{#4}}
187   \cs_new:cpn {#1vectoronlyderivedunits} {\mandi@selectderivedunits{#2}{#3}{#4}}
188   \cs_new:cpn {vector#1onlyalternateunits} {\mandi@selectalternateunits{#2}{#3}{#4}}
189   \cs_new:cpn {#1vectoronlyalternateunits} {\mandi@selectalternateunits{#2}{#3}{#4}}
190 }

```

```

191 \NewDocumentCommand{\newvectorquantity}{ m m O{#2} O{#2} }
192 {
193   \__mandi_newvectorquantity:nnnn { #1 }{ #2 }{ #3 }{ #4 }
194 }
195 \ExplSyntaxOff

```

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

```

196 \ExplSyntaxOn
197 \cs_new:Npn \__mandi_renewvectorquantity:nnnn #1#2#3#4
198 {
199   \__mandi_renewscalarquantity:nnnn { #1 }{ #2 }{ #3 }{ #4 }
200   \cs_set:cpn {vector#1} ##1 {\unit{\mivector{##1}}{\mandi@selectunits{#2}{#3}{#4}}}
201   \cs_set:cpn {#1vector} ##1 {\unit{\mivector{##1}}{\mandi@selectunits{#2}{#3}{#4}}}
202   \cs_set:cpn {vector#1value} ##1 {\mivector{##1}}
203   \cs_set:cpn {#1vectorvalue} ##1 {\mivector{##1}}
204   \cs_set:cpn {vector#1baseunits} ##1 {\unit{\mivector{##1}}{\mandi@selectbaseunits{#2}{#3}{#4}}}
205   \cs_set:cpn {#1vectorbaseunits} ##1 {\unit{\mivector{##1}}{\mandi@selectbaseunits{#2}{#3}{#4}}}
206   \cs_set:cpn {vector#1derivedunits} ##1 {\unit{\mivector{##1}}{\mandi@selectderivedunits{#2}{#3}{#4}}}
207   \cs_set:cpn {#1vectorderivedunits} ##1 {\unit{\mivector{##1}}{\mandi@selectderivedunits{#2}{#3}{#4}}}
208   \cs_set:cpn {vector#1alternateunits} ##1 {\unit{\mivector{##1}}{\mandi@selectalternateunits{#2}{#3}{#4}}}
209   \cs_set:cpn {#1vectoralternateunits} ##1 {\unit{\mivector{##1}}{\mandi@selectalternateunits{#2}{#3}{#4}}}
210   \cs_set:cpn {vector#1onlybaseunits} {\mandi@selectbaseunits{#2}{#3}{#4}}
211   \cs_set:cpn {#1vectoronlybaseunits} {\mandi@selectbaseunits{#2}{#3}{#4}}
212   \cs_set:cpn {vector#1onlyderivedunits} {\mandi@selectderivedunits{#2}{#3}{#4}}
213   \cs_set:cpn {#1vectoronlyderivedunits} {\mandi@selectderivedunits{#2}{#3}{#4}}
214   \cs_set:cpn {vector#1onlyalternateunits} {\mandi@selectalternateunits{#2}{#3}{#4}}
215   \cs_set:cpn {#1vectoronlyalternateunits} {\mandi@selectalternateunits{#2}{#3}{#4}}
216 }
217 \NewDocumentCommand{\renewvectorquantity}{ m m O{#2} O{#2} }
218 {
219   \__mandi_renewvectorquantity:nnnn { #1 }{ #2 }{ #3 }{ #4 }
220 }
221 \ExplSyntaxOff

```

Defining a new physical constant.

```

222 \ExplSyntaxOn
223 \cs_new:Npn \__mandi_newphysicalconstant:nnnnnn #1#2#3#4#5#6#7
224 {
225   \cs_new:cpn {#1} {\unit{\mandi@selectprecision{#3}{#4}}{\mandi@selectunits{#5}{#6}{#7}}}
226   \cs_new:cpn {#1mathsymbol} {#2}
227   \cs_new:cpn {#1approximatevalue} {#3}
228   \cs_new:cpn {#1precisevalue} {#4}
229   \cs_new:cpn {#1baseunits}
230     {\unit{\mandi@selectprecision{#3}{#4}}{\mandi@selectbaseunits{#5}{#6}{#7}}}
231   \cs_new:cpn {#1derivedunits}
232     {\unit{\mandi@selectprecision{#3}{#4}}{\mandi@selectderivedunits{#5}{#6}{#7}}}
233   \cs_new:cpn {#1alternateunits}
234     {\unit{\mandi@selectprecision{#3}{#4}}{\mandi@selectalternateunits{#5}{#6}{#7}}}
235   \cs_new:cpn {#1onlybaseunits} {\mandi@selectbaseunits{#5}{#6}{#7}}
236   \cs_new:cpn {#1onlyderivedunits} {\mandi@selectderivedunits{#5}{#6}{#7}}
237   \cs_new:cpn {#1onlyalternateunits} {\mandi@selectalternateunits{#5}{#6}{#7}}
238 }
239 \NewDocumentCommand{\newphysicalconstant}{ m m m m m O{#5} O{#5} }
240 {
241   \__mandi_newphysicalconstant:nnnnnn { #1 }{ #2 }{ #3 }{ #4 }{ #5 }{ #6 }{ #7 }
242 }
243 \ExplSyntaxOff

```

Redefining an existing physical constant.

```

244 \ExplSyntaxOn
245 \cs_new:Npn \__mandi_renewphysicalconstant:nnnnnnn #1#2#3#4#5#6#7
246 {
247   \cs_set:cpn {#1} {\unit{\mandi@selectprecision{#3}{#4}}{\mandi@selectunits{#5}{#6}{#7}}}
248   \cs_set:cpn {#1mathsymbol} {#2}
249   \cs_set:cpn {#1approximatevalue} {#3}
250   \cs_set:cpn {#1precisevalue} {#4}
251   \cs_set:cpn {#1baseunits}
252     {\unit{\mandi@selectprecision{#3}{#4}}{\mandi@selectbaseunits{#5}{#6}{#7}}}
253   \cs_set:cpn {#1derivedunits}
254     {\unit{\mandi@selectprecision{#3}{#4}}{\mandi@selectderivedunits{#5}{#6}{#7}}}
255   \cs_set:cpn {#1alternateunits}
256     {\unit{\mandi@selectprecision{#3}{#4}}{\mandi@selectalternateunits{#5}{#6}{#7}}}
257   \cs_set:cpn {#1onlybaseunits} {\mandi@selectbaseunits{#5}{#6}{#7}}
258   \cs_set:cpn {#1onlyderivedunits} {\mandi@selectderivedunits{#5}{#6}{#7}}
259   \cs_set:cpn {#1onlyalternateunits} {\mandi@selectalternateunits{#5}{#6}{#7}}
260 }
261 \NewDocumentCommand{\renewphysicalconstant}{m m m m m m 0{#5} 0{#5} }
262 {
263   \__mandi_renewphysicalconstant:nnnnnnn { #1 }{ #2 }{ #3 }{ #4 }{ #5 }{ #6 }{ #7 }
264 }
265 \ExplSyntaxOff

```

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

```

266 \newvectorquantity{acceleration}%
267   {\meter\usk\second\totheinversetwo}%
268   [\newton\per\kilogram]%
269   [\meter\per\second\tothetwo]%
270 \newscalarquantity{amount}%
271   {\mole}%
272 \newvectorquantity{angularacceleration}%
273   {\radian\usk\second\totheinversetwo}%
274   [\radian\per\second\tothetwo]%
275   [\radian\per\second\tothetwo]%
276 \newscalarquantity{angularfrequency}%
277   {\radian\usk\second\inverse}%
278   [\radian\per\second]%
279   [\radian\per\second]%
280 %\ifmandi@rotradians
281 %   \newphysicalquantity{angularimpulse}%
282 %     {\meter\tothetwo\usk\kilogram\usk\second\inverse\usk\radian\inverse}%
283 %     [\joule\usk\second\per\radian]%
284 %     [\newton\usk\meter\usk\second\per\radian]%
285 %   \newphysicalquantity{angularmomentum}%
286 %     {\meter\tothetwo\usk\kilogram\usk\second\inverse\usk\radian\inverse}%
287 %     [\kilogram\usk\meter\tothetwo\per(\second\usk\radian)]%
288 %     [\newton\usk\meter\usk\second\per\radian]%
289 %\else
290 \newvectorquantity{angularimpulse}%
291   {\kilogram\usk\meter\tothetwo\usk\second\inverse}%
292   [\kilogram\usk\meter\tothetwo\per\second] % also \joule\usk\second
293   [\kilogram\usk\meter\tothetwo\per\second] % also \newton\usk\meter\usk\second
294 \newvectorquantity{angularmomentum}%
295   {\kilogram\usk\meter\tothetwo\usk\second\inverse}%
296   [\kilogram\usk\meter\tothetwo\per\second] % also \joule\usk\second
297   [\kilogram\usk\meter\tothetwo\per\second] % also \newton\usk\meter\usk\second
298 %\fi

```



```

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

```

```

358 [\newton\per\coulomb]%
359 \newscalarquantity{electricflux}%
360 {\kilogram\usk\meter\tothethree\usk\ampere\inverse\usk\second\totheinversethree}%
361 [\volt\usk\meter]%
362 [\newton\usk\meter\tothetwo\per\coulomb]%
363 \newscalarquantity{electricpotential}%
364 {\kilogram\usk\meter\tothetwo\usk\ampere\inverse\usk\second\totheinversethree}%
365 [\volt]% % also \joule\per\coulomb
366 [\volt]%
367 \newscalarquantity{electricpotentialdifference}%
368 {\kilogram\usk\meter\tothetwo\usk\ampere\inverse\usk\second\totheinversethree}%
369 [\volt]% % also \joule\per\coulomb
370 [\volt]%
371 \newscalarquantity{electroncurrent}%
372 {\second\inverse}%
373 [\ensuremath{\mathrm{e}}\per\second]%
374 [\ensuremath{\mathrm{e}}\per\second]%
375 \newscalarquantity{emf}%
376 {\kilogram\usk\meter\tothetwo\usk\ampere\inverse\usk\second\totheinversethree}%
377 [\volt]% % also \joule\per\coulomb
378 [\volt]%
379 \newscalarquantity{energy}%
380 {\kilogram\usk\meter\tothetwo\usk\second\totheinversetwo}%
381 [\joule]% % also \newton\usk\meter
382 [\joule]%
383 \newscalarquantity{energyinev}%
384 {\electronvolt}%
385 \newscalarquantity{energyinkev}%
386 {\kilolectronvolt}%
387 \newscalarquantity{energyinmev}%
388 {\megaelectronvolt}%
389 \newscalarquantity{energydensity}%
390 {\kilogram\usk\meter\inverse\usk\second\totheinversetwo}%
391 [\joule\per\meter\tothethree]%
392 [\joule\per\meter\tothethree]%
393 \newscalarquantity{energyflux}%
394 {\kilogram\usk\second\totheinversethree}%
395 [\watt\per\meter\tothetwo]%
396 [\watt\per\meter\tothetwo]%
397 \newscalarquantity{entropy}%
398 {\kilogram\usk\meter\tothetwo\usk\second\totheinversetwo\usk\kelvin\inverse}%
399 [\joule\per\kelvin]%
400 [\joule\per\kelvin]%
401 \newvectorquantity{force}%
402 {\kilogram\usk\meter\usk\second\totheinversetwo}%
403 [\newton]%
404 [\newton]% % also \kilogram\usk\meter\per\second\tothetwo
405 \newscalarquantity{frequency}%
406 {\second\inverse}%
407 [\hertz]%
408 [\hertz]%
409 \newvectorquantity{gravitationalfield}%
410 {\meter\usk\second\totheinversetwo}%
411 [\newton\per\kilogram]%
412 [\newton\per\kilogram]%
413 \newscalarquantity{gravitationalpotential}%
414 {\meter\tothetwo\usk\second\totheinversetwo}%
415 [\joule\per\kilogram]%
416 [\joule\per\kilogram]%

```

```

417 \newscalarquantity{gravitationalpotentialdifference}%
418   {\meter\tothetwo\usk\second\totheinversetwo}%
419   [\joule\per\kilogram]%
420   [\joule\per\kilogram]%
421 \newvectorquantity{impulse}%
422   {\kilogram\usk\meter\usk\second\inverse}%
423   [\newton\usk\second]%
424   [\newton\usk\second]%
425 \newscalarquantity{indexofrefraction}%
426   {}%
427 \newscalarquantity{inductance}%
428   {\kilogram\usk\meter\tothetwo\usk\ampere\totheinversetwo\usk\second\totheinversetwo}%
429   [\henry]%
430   [\volt\usk\second\per\ampere]% % also \square\meter\usk\kilogram\per\coulomb\tothetwo, \Wb\per\ampere
431 \newscalarquantity{linearchargedensity}%
432   {\ampere\usk\second\usk\meter\inverse}%
433   [\coulomb\per\meter]%
434   [\coulomb\per\meter]%
435 \newscalarquantity{linearmassdensity}%
436   {\kilogram\usk\meter\inverse}%
437   [\kilogram\per\meter]%
438   [\kilogram\per\meter]%

439 \newscalarquantity{lorentzfactor}%
440   {}%
441 \newscalarquantity{luminousintensity}%
442   {\candela}%
443 \newscalarquantity{magneticcharge}%
444   {\ampere\usk\meter}% % There is another convention. Be careful!
445 \newvectorquantity{magneticdipolemoment}%
446   {\ampere\usk\meter\tothetwo}%
447   [\ampere\usk\meter\tothetwo]%
448   [\joule\per\tesla]%
449 \newvectorquantity{magneticfield}%
450   {\kilogram\usk\ampere\inverse\usk\second\totheinversetwo}%
451   [\newton\per\ampere\usk\meter]% % also \Wb\per\meter\tothetwo
452   [\tesla]%
453 \newscalarquantity{magneticflux}%
454   {\kilogram\usk\meter\tothetwo\usk\ampere\inverse\usk\second\totheinversetwo}%
455   [\tesla\usk\meter\tothetwo]%
456   [\volt\usk\second]% % also \Wb and \joule\per\ampere
457 \newscalarquantity{mass}%
458   {\kilogram}%
459 \newscalarquantity{mobility}%
460   {\kilogram\usk\meter\tothetwo\usk\ampere\inverse\usk\second\totheinversefour}%
461   [\meter\tothetwo\per\volt\usk\second]%
462   [\coulomb\usk\meter\per\newton\usk\second]%
463 \newscalarquantity{momentofinertia}%
464   {\kilogram\usk\meter\tothetwo}%
465   [\joule\usk\second\tothetwo]%
466   [\kilogram\usk\meter\tothetwo]%
467 \newvectorquantity{momentum}%
468   {\kilogram\usk\meter\usk\second\inverse}%
469   [\kilogram\usk\meter\per\second]%
470   [\kilogram\usk\meter\per\second]%
471 \newvectorquantity{momentumflux}%
472   {\kilogram\usk\meter\inverse\usk\second\totheinversetwo}%
473   [\newton\per\meter\tothetwo]%
474   [\newton\per\meter\tothetwo]%

```

```

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

```

```

534 {\kilogram\usk\meter\inverse\usk\second\totheinversetwo}%
535 [\pascal]%
536 [\newton\per\meter\tothetwo]%
537 \newsclarquantity{strain}%
538 {}%
539 \newsclarquantity{temperature}%
540 {\kelvin}%
541 %\ifmandi@rotradians
542 % \newphysicalquantity{torque}%
543 % {\kilogram\usk\meter\tothetwo\usk\second\totheinversetwo\usk\radian\inverse}%
544 % [\newton\usk\meter\per\radian]%
545 % [\newton\usk\meter\per\radian]%
546 %\else
547 \newvectorquantity{torque}%
548 {\kilogram\usk\meter\tothetwo\usk\second\totheinversetwo}%
549 [\newton\usk\meter]%
550 [\newton\usk\meter]%
551 %\fi
552 \newvectorquantity{velocity}%
553 {\meter\usk\second\inverse}%
554 [\meter\per\second]%
555 [\meter\per\second]%
556 \newvectorquantity{velocityc}%
557 {\lightspeed}%
558 [\lightspeed]%
559 [\lightspeed]%
560 \newsclarquantity{volume}%
561 {\meter\tothethree}%
562 \newsclarquantity{volumechargeddensity}%
563 {\ampere\usk\second\per\meter\totheinversethree}%
564 [\coulomb\per\meter\tothethree]%
565 [\coulomb\per\meter\tothethree]%
566 \newsclarquantity{volumemassdensity}%
567 {\kilogram\usk\meter\totheinversethree}%
568 [\kilogram\per\meter\tothethree]%
569 [\kilogram\per\meter\tothethree]%
570 \newsclarquantity{wavelength}% % This is really just a displacement.
571 {\meter}%
572 \newvectorquantity{wavenumber}%
573 {\meter\inverse}%
574 [\per\meter]%
575 [\per\meter]%
576 \newsclarquantity{work}%
577 {\kilogram\usk\meter\tothetwo\usk\second\totheinversetwo}%
578 [\joule]% % also \newton\usk\meter but discouraged
579 [\joule]%
580 \newsclarquantity{youngsmodulus}% % This is really just a stress.
581 {\kilogram\usk\meter\inverse\usk\second\totheinversetwo}%
582 [\pascal]%
583 [\newton\per\meter\tothetwo]%

```

We need a better glyph for Planck's constant over  $2\pi$ .

```

584 \AtBeginDocument{%
585 \DeclareRobustCommand{\hbar}{\mathpalette\hbar@relax\symup{h}}%
586 }%
587 \newcommand*{\hbar@}[2]{%
588 \makebox[0pt][l]{\raisebox{-0.07\height}{\(\m@th#1\mkern-2mu\mathchar"AF\)}}%
589 % optional line to make the bar thicker; must use -0.11
590 \makebox[0pt][l]{\raisebox{-0.11\height}{\(\m@th#1\mkern-2mu\mathchar"AF\)}}%

```

591 }%

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

```

592 \newphysicalconstant{avogadro}%
593   {\symup{N_A}}%
594   {6\times10^{23}}{6.02214076\times10^{23}}% % exact 2019 value
595   {\mole\inverse}%
596   [\per\mole]%
597   [\per\mole]%
598 \newphysicalconstant{biotsavartconstant}% % alias for \mzofp
599   {\symup{\frac{\mu_o}{4\pi}}}%
600   {10^{-7}}{10^{-7}}%
601   {\kilogram\usk\meter\usk\ampere\totheinversetwo\usk\second\totheinversetwo}%
602   [\henry\per\meter]%
603   [\tesla\usk\meter\per\ampere]%
604 \newphysicalconstant{bohrradius}%
605   {\symup{a_o}}%
606   {5.3\times10^{-11}}{5.29177210903\times10^{-11}}%
607   {\meter}%
608 \newphysicalconstant{boltzmann}%
609   {\symup{k_B}}%
610   {1.4\times10^{-23}}{1.380649\times10^{-23}}% % exact 2019 value
611   {\kilogram\usk\meter\tothetwo\usk\second\totheinversetwo\usk\kelvin\inverse}%
612   [\joule\per\kelvin]%
613   [\joule\per\kelvin]%
614 \newphysicalconstant{coulombconstant}% % alias for \oofpez
615   {\symup{\frac{1}{4\pi\epsilon_o}}}%
616   {9\times10^9}{8.9875517923\times10^9}%
617   {\kilogram\usk\meter\tothethree\usk\ampere\totheinversetwo\usk\second\totheinversefour}%
618   [\meter\per\farad]%
619   [\newton\usk\meter\tothetwo\per\coulomb\tothetwo]%
620 \newphysicalconstant{earthmass}%
621   {\symup{M_{Earth}}}%
622   {6.0\times10^{24}}{5.9722\times10^{24}}%
623   {\kilogram}%
624 \newphysicalconstant{earthmoondistance}%
625   {\symup{d_{EM}}}%
626   {3.8\times10^8}{3.81550\times10^8}%
627   {\meter}%
628 \newphysicalconstant{earthradius}%
629   {\symup{R_{Earth}}}%
630   {6.4\times10^6}{6.3781\times10^6}%
631   {\meter}%
632 \newphysicalconstant{earthsundistance}%
633   {\symup{d_{ES}}}%
634   {1.5\times10^{11}}{1.496\times10^{11}}%
635   {\meter}%
636 \newphysicalconstant{electroncharge}%
637   {\symup{q_e}}%
638   {-\elementarychargeapproximatevalue}{-\elementarychargeprecisevalue}%
639   {\ampere\usk\second}%
640   [\coulomb]%
641   [\coulomb]%
642 \newphysicalconstant{electronCharge}%
643   {\symup{Q_e}}%
644   {-\elementarychargeapproximatevalue}{-\elementarychargeprecisevalue}%
645   {\ampere\usk\second}%
646   [\coulomb]%
647   [\coulomb]%

```

```

648 \newphysicalconstant{electronmass}%
649 {\symup{m_e}}%
650 {9.1\times10^{-31}}{9.1093837015\times10^{-31}}%
651 {\kilogram}%
652 \newphysicalconstant{elementarycharge}%
653 {\symup{e}}%
654 {1.6\times10^{-19}}{1.602176634\times10^{-19}}% % exact 2019 value
655 {\ampere\usk\second}%
656 [\coulomb]%
657 [\coulomb]%
658 \newphysicalconstant{finestructure}%
659 {\symup{\alpha}}%
660 {\frac{1}{137}}{7.2973525693\times10^{-3}}%
661 {}%
662 \newphysicalconstant{hydrogenmass}%
663 {\symup{m_H}}%
664 {1.7\times10^{-27}}{1.6737236\times10^{-27}}%
665 {\kilogram}%
666 \newphysicalconstant{moonearthdistance}%
667 {\symup{d_{ME}}}%
668 {3.8\times10^8}{3.81550\times10^8}%
669 {\meter}%
670 \newphysicalconstant{moonmass}%
671 {\symup{M_{Moon}}}%
672 {7.3\times10^{22}}{7.342\times10^{22}}%
673 {\kilogram}%
674 \newphysicalconstant{moonradius}%
675 {\symup{R_{Moon}}}%
676 {1.7\times10^6}{1.7371\times10^6}%
677 {\meter}%
678 \newphysicalconstant{mzofp}%
679 {\symup{\frac{1}{4\pi\epsilon_0}}}%
680 {10^{-7}}{10^{-7}}%
681 {\kilogram\usk\meter\usk\ampere\totheinversetwo\usk\second\totheinversetwo}%
682 [\henry\per\meter]%
683 [\tesla\usk\meter\per\ampere]%
684 \newphysicalconstant{neutronmass}%
685 {\symup{m_n}}%
686 {1.7\times10^{-27}}{1.67492749804\times10^{-27}}%
687 {\kilogram}%
688 \newphysicalconstant{oofpez}%
689 {\symup{\frac{1}{4\pi\epsilon_0}}}%
690 {9\times10^9}{8.9875517923\times10^9}%
691 {\kilogram\usk\meter\tothethree\usk\ampere\totheinversetwo\usk\second\totheinversefour}%
692 [\meter\per\farad]%
693 [\newton\usk\meter\tothetwo\per\coulomb\tothetwo]%
694 \newphysicalconstant{oofpezcs}%
695 {\symup{\frac{1}{4\pi\epsilon_0 c^2}}}%
696 {10^{-7}}{10^{-7}}%
697 {\kilogram\usk\meter\usk\ampere\totheinversetwo\usk\second\totheinversetwo}%
698 [\tesla\usk\meter\tothetwo]%
699 [\newton\usk\second\tothetwo\per\coulomb\tothetwo]%
700 \newphysicalconstant{planck}%
701 {\symup{h}}%
702 {6.6\times10^{-34}}{6.62607015\times10^{-34}}% % exact 2019 value
703 {\kilogram\usk\meter\tothetwo\usk\second\inverse}%
704 [\joule\usk\second]%
705 [\joule\usk\second]%

```

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

```

706 \newphysicalconstant{planckbar}%
707   {\hbar}%
708   {1.1\mathrm{times}10^{-34}}{1.054571817\mathrm{times}10^{-34}}%
709   {\kilogram\uskmeter\tothetwo\usks\second\inverse}%
710   [\joule\usks\second]%
711   [\joule\usks\second]
712 \newphysicalconstant{planckc}%
713   {\symup{hc}}%
714   {2.0\mathrm{times}10^{-25}}{1.98644586\mathrm{times}10^{-25}}%
715   {\kilogram\uskmeter\tothethree\usks\second\totheinversetwo}%
716   [\joule\usks\meter]%
717   [\joule\usks\meter]
718 \newphysicalconstant{protoncharge}%
719   {\symup{q_p}}%
720   {+\elementarychargeapproximatevalue}{+\elementarychargeprecisevalue}%
721   {\ampere\usks\second}%
722   [\coulomb]%
723   [\coulomb]
724 \newphysicalconstant{protonCharge}%
725   {\symup{Q_p}}%
726   {+\elementarychargeapproximatevalue}{+\elementarychargeprecisevalue}%
727   {\ampere\usks\second}%
728   [\coulomb]%
729   [\coulomb]
730 \newphysicalconstant{protonmass}%
731   {\symup{m_p}}%
732   {1.7\mathrm{times}10^{-27}}{1.672621898\mathrm{times}10^{-27}}%
733   {\kilogram}%
734 \newphysicalconstant{rydberg}%
735   {\symup{R_{\infty}}}%
736   {1.1\mathrm{times}10^7}{1.0973731568160\mathrm{times}10^7}%
737   {\meter\inverse}%
738 \newphysicalconstant{speedoflight}%
739   {\symup{c}}%
740   {3\mathrm{times}10^8}{2.99792458\mathrm{times}10^8}} % exact value
741   {\meter\usks\second\inverse}%
742   [\meter\per\second]%
743   [\meter\per\second]
744 \newphysicalconstant{stefanboltzmann}%
745   {\symup{\sigma}}%
746   {5.7\mathrm{times}10^{-8}}{5.670374\mathrm{times}10^{-8}}%
747   {\kilogram\usks\second\totheinversethree\usks\kelvin\totheinversefour}%
748   [\watt\per\meter\tothetwo\usks\kelvin\tothefour]%
749   [\watt\per\meter\tothetwo\usks\kelvin\tothefour]
750 \newphysicalconstant{sunearthdistance}%
751   {\symup{d_{SE}}}%
752   {1.5\mathrm{times}10^{11}}{1.496\mathrm{times}10^{11}}%
753   {\meter}%
754 \newphysicalconstant{sunmass}%
755   {\symup{M_{Sun}}}%
756   {2.0\mathrm{times}10^{30}}{1.98855\mathrm{times}10^{30}}%
757   {\kilogram}%
758 \newphysicalconstant{sunradius}%
759   {\symup{R_{Sun}}}%
760   {7.0\mathrm{times}10^8}{6.957\mathrm{times}10^8}}%
761   {\meter}%
762 \newphysicalconstant{surfacegravfield}%

```



```

763 {\symup{g}}%
764 {9.8}{9.807}%
765 {\meter\usk\second\totheinversetwo}%
766 [\newton\per\kilogram]%
767 [\newton\per\kilogram]%
768 \newphysicalconstant{universalgrav}%
769 {\symup{G}}%
770 {6.7\times10^{-11}}{6.67430\times10^{-11}}%
771 {\meter\tothethree\usk\kilogram\inverse\usk\second\totheinversetwo}%
772 [\newton\usk\meter\tothetwo\per\kilogram\tothetwo] % also \joule\usk\meter\per\kilogram\tothetwo
773 [\newton\usk\meter\tothetwo\per\kilogram\tothetwo]%
774 \newphysicalconstant{vacuumpermeability}%
775 {\symup{\mu_o}}%
776 {4\pi\times10^{-7}}{4\pi\times10^{-7}} % as of 2018 no longer 4\pi\times10^{-7}
777 {\kilogram\usk\meter\usk\ampere\totheinversetwo\usk\second\totheinversetwo}%
778 [\henry\per\meter]%
779 [\tesla\usk\meter\per\ampere]%
780 \newphysicalconstant{vacuumpermittivity}%
781 {\symup{\epsilon_o}}%
782 {9\times10^{-12}}{8.854187817\times10^{-12}}%
783 {\ampere\tothetwo\usk\second\tothefour\usk\kilogram\inverse\usk\meter\totheinversethree}%
784 [\farad\per\meter]%
785 [\coulomb\tothetwo\per\newton\usk\meter\tothetwo]%

```

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

```

786 \ExplSyntaxOn
787 \NewDocumentCommand{\@aux}{ m }
788 {
789   \use:c { #1 }
790 }
791 \NewDocumentCommand{\@auy}{ m }
792 {
793   \normalfont\ttfamily\token_to_str:c { #1 }
794 }
795 \ExplSyntaxOff
796 \newcolumnntype{M}{>{\(}\p{0.25\linewidth}<{\)}}
797 \NewDocumentCommand{\checkquantity}{ m }
798 {%
799   \begin{center}
800     \begin{tabular}{MMM}
801       \textbf{command} & & \multicolumn{2}{l}{\@auy{#1}} & \tabularnewline
802       \text{\textbf{base}} & & \text{\textbf{derived}} & & \text{\textbf{alternate}} & \tabularnewline
803       \@aux{#1onlybaseunits} & & \@aux{#1onlyderivedunits} & & \@aux{#1onlyalternateunits} & \tabularnewline
804     \end{tabular}
805   \end{center}
806 }%
807 \NewDocumentCommand{\checkconstant}{ m }
808 {%
809   \begin{center}
810     \begin{tabular}{MMM}
811       \textbf{command} & & \multicolumn{2}{l}{\@auy{#1}} & \tabularnewline
812       \text{\textbf{symbol}} & & \text{\textbf{approximate}} & & \text{\textbf{precise}} & \tabularnewline
813       \@aux{#1mathsymbol} & & \@aux{#1approximatevalue} & & \@aux{#1precisevalue} & \tabularnewline
814       \text{\textbf{base}} & & \text{\textbf{derived}} & & \text{\textbf{alternate}} & \tabularnewline
815       \@aux{#1onlybaseunits} & & \@aux{#1onlyderivedunits} & & \@aux{#1onlyalternateunits} & \tabularnewline
816     \end{tabular}
817   \end{center}
818 }%

```

`\mivector`<sup>P.34</sup> is a workhorse command.

See <https://tex.stackexchange.com/a/39054/218142>.

```
819 \ExplSyntaxOn
820 \NewDocumentCommand{\mivector}{0{,} m o }
821 {
822   \__mandi_vector:nn { #1 } { #2 }
823   \IfValueT{#3}{\,{#3}}
824 }
825 \seq_new:N \l__mandi_list_seq
826 \cs_new_protected:Npn \__mandi_vector:nn #1#2
827 {
828   \seq_set_split:Nnn \l__mandi_list_seq { , } { #2 }
829   \int_compare:nT { \seq_count:N \l__mandi_list_seq = 1 }
830   {
831     \msg_new:nnnn { mandi } { onecomponent }
832     {
833       More~than~one~component~expected.      \iow_newline:
834       You~provided~one~component~to~a~command \iow_newline:
835       that~expects~a~vector.~Either~you~don't \iow_newline:
836       need~a~vector~here~or~you~didn't~supply \iow_newline:
837       all~the~components.
838     }
839     {
840       Decide~whether~or~not~you~really~need~a~vector~command~here. \iow_newline:
841       \msg_see_documentation_text:n { mandi }
842     }
843     \msg_fatal:nn { mandi } { onecomponent }
844   }
845 }
846 \left\langle
847   \seq_use:Nnnn \l__mandi_list_seq { #1 } { #1 } { #1 }
848 \right\rangle
849 }
850 \ExplSyntaxOff
```

## 5 The mandistudent Package

mandi comes with an accessory package `mandistudent`, which provides a collection of commands physics students can use for writing problem solutions. This package focuses on the most frequently needed tools. These commands should always be used in math mode. Note that `mandistudent` requires, and loads, `mandi` but `mandi` doesn't require, and doesn't load, `mandistudent`.

Load `mandistudent` as you would any package in your preamble. There are no package options.

```
\usepackage{mandistudent}
```

```
\mandistudentversion
```

Typesets the current version and build date.

```
The version is \mandistudentversion\ and is a stable build.
```

```
The version is v3.0.2 dated 2021-12-05 and is a stable build.
```

### 5.1 Traditional Vector Notation

U 2021-09-18

U 2021-09-18

```
\vec{\langle symbol \rangle} [\langle labels \rangle]
```

(use this variant for boldface notation)

```
\vec*{\langle symbol \rangle} [\langle labels \rangle]
```

(use this variant for arrow notation)

Powerful and intelligent command for symbolic vector notation. The mandatory argument is the symbol for the vector quantity. The optional label(s) consists of superscripts and/or subscripts and can be mathematical or textual in nature. If textual, be sure to wrap them in `\symup{...}` for proper typesetting. The starred variant gives arrow notation whereas without the star you get boldface notation. Subscript and superscript labels can be arbitrarily mixed, and order doesn't matter. This command redefines the default  $\text{\LaTeX 2}_{\epsilon}$  `\vec` command.

```
\( \vec{p} ) \qquad \qquad \qquad \\
\(\ \vec{p}_{2} ) \qquad \qquad \qquad \\
\(\ \vec{p}^{\symup{ball}} ) \qquad \qquad \qquad \\
\(\ \vec{p}_{\symup{final}} ) \qquad \qquad \qquad \\
\(\ \vec{p}^{\symup{ball}}_{\symup{final}} ) \qquad \qquad \qquad \\
\(\ \vec{p}^{\symup{final}}_{\symup{ball}} ) \qquad \qquad \qquad \\
\(\ \vec*{p} ) \qquad \qquad \qquad \\
\(\ \vec*{p}_{2} ) \qquad \qquad \qquad \\
\(\ \vec*{p}^{\symup{ball}} ) \qquad \qquad \qquad \\
\(\ \vec*{p}_{\symup{final}} ) \qquad \qquad \qquad \\
\(\ \vec*{p}^{\symup{ball}}_{\symup{final}} ) \qquad \qquad \qquad \\
\(\ \vec*{p}^{\symup{final}}_{\symup{ball}} ) \qquad \qquad \qquad
```

$p$   
 $p_2$   
 $p_{\text{ball}}$   
 $p_{\text{ball}}^{\text{final}}$   
 $p_{\text{final}}^{\text{final}}$   
 $p_{\text{ball}}^{\text{final}}$   
 $\vec{p}$   
 $\vec{p}_2$   
 $\vec{p}_{\text{ball}}$   
 $\vec{p}_{\text{final}}$   
 $\vec{p}_{\text{ball}}^{\text{final}}$   
 $\vec{p}_{\text{final}}^{\text{final}}$

U 2021-09-18

```
\dirvec{\langle symbol \rangle} [\langle labels \rangle]
```

(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>	$\widehat{p}$
<code>\( \dirvec{p}_{2} \)</code>	<code>\)</code>	$\widehat{p}_2$
<code>\( \dirvec{p}^{\mathrm{ball}} \)</code>	<code>\)</code>	$\widehat{p}_{\mathrm{ball}}$
<code>\( \dirvec{p}_{\mathrm{final}} \)</code>	<code>\)</code>	$\widehat{p}_{\mathrm{final}}$
<code>\( \dirvec{p}^{\mathrm{ball}}_{\mathrm{final}} \)</code>	<code>\)</code>	$\widehat{p}_{\mathrm{ball}}^{\mathrm{final}}$
<code>\( \dirvec{p}_{\mathrm{final}}^{\mathrm{ball}} \)</code>	<code>\)</code>	$\widehat{p}_{\mathrm{ball}}^{\mathrm{final}}$
<code>\( \dirvec*{p} \)</code>	<code>\)</code>	$\widehat{p}$
<code>\( \dirvec*{p}_{2} \)</code>	<code>\)</code>	$\widehat{p}_2$
<code>\( \dirvec*{p}^{\mathrm{ball}} \)</code>	<code>\)</code>	$\widehat{p}_{\mathrm{ball}}$
<code>\( \dirvec*{p}_{\mathrm{final}} \)</code>	<code>\)</code>	$\widehat{p}_{\mathrm{final}}$
<code>\( \dirvec*{p}^{\mathrm{ball}}_{\mathrm{final}} \)</code>	<code>\)</code>	$\widehat{p}_{\mathrm{ball}}^{\mathrm{final}}$
<code>\( \dirvec*{p}_{\mathrm{final}}^{\mathrm{ball}} \)</code>	<code>\)</code>	$\widehat{p}_{\mathrm{ball}}^{\mathrm{final}}$

**`\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.

<code>\( \zerovec \)</code>	<code>\)</code>	$\mathbf{0}$
<code>\( \zerovec* \)</code>	<code>\)</code>	$\vec{0}$

**`\changein`**

Semantic alias for `\Delta`.

<code>\( \changein t \)</code>	<code>\)</code>	$\Delta t$
<code>\( \changein \vec{p} \)</code>	<code>\)</code>	$\Delta p$

**`\doublebars[⟨size⟩]{⟨quantity⟩}`** (double bars)  
**`\doublebars*[⟨size⟩]{⟨quantity⟩}`** (double bars for fractions)  
**`\singlebars[⟨size⟩]{⟨quantity⟩}`** (single bars)  
**`\singlebars*[⟨size⟩]{⟨quantity⟩}`** (single bars for fractions)  
**`\anglebrackets[⟨size⟩]{⟨quantity⟩}`** (angle brackets)  
**`\anglebrackets*[⟨size⟩]{⟨quantity⟩}`** (angle brackets for fractions)  
**`\parentheses[⟨size⟩]{⟨quantity⟩}`** (parentheses)  
**`\parentheses*[⟨size⟩]{⟨quantity⟩}`** (parentheses for fractions)  
**`\squarebrackets[⟨size⟩]{⟨quantity⟩}`** (square brackets)  
**`\squarebrackets*[⟨size⟩]{⟨quantity⟩}`** (square brackets for fractions)

`\curlybraces[<size>]{<quantity>}` (curly braces)  
`\curlybraces*[<size>]{<quantity>}` (curly braces for fractions)

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

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

$\backslash[ \ \squarebrackets{} \ \backslash]$	$[\cdot]$
$\backslash[ \ \squarebrackets{x} \ \backslash]$	$[x]$
$\backslash[ \ \squarebrackets*{\frac{x}{3}} \ \backslash]$	$\left[\frac{x}{3}\right]$
$\backslash[ \ \squarebrackets[\Big]{\frac{x}{3}} \ \backslash]$	$\left[\frac{x}{3}\right]$

$\backslash[ \ \curlybraces{} \ \backslash]$	$\{\cdot\}$
$\backslash[ \ \curlybraces{x} \ \backslash]$	$\{x\}$
$\backslash[ \ \curlybraces*{\frac{x}{3}} \ \backslash]$	$\left\{\frac{x}{3}\right\}$
$\backslash[ \ \curlybraces[\Big]{\frac{x}{3}} \ \backslash]$	$\left\{\frac{x}{3}\right\}$

<small>N 2021-02-21</small>	$\backslash\textbf{magnitude}[\langle size \rangle]{\langle quantity \rangle}$	(alias for double bars)
<small>N 2021-02-21</small>	$\backslash\textbf{magnitude}^*[\langle size \rangle]{\langle quantity \rangle}$	(alias for double bars for fractions)
<small>N 2021-02-21</small>	$\backslash\textbf{norm}[\langle size \rangle]{\langle quantity \rangle}$	(alias for double bars)
<small>N 2021-02-21</small>	$\backslash\textbf{norm}^*[\langle size \rangle]{\langle quantity \rangle}$	(alias for double bars for fractions)
<small>N 2021-02-21</small>	$\backslash\textbf{absolutevalue}[\langle size \rangle]{\langle quantity \rangle}$	(alias for single bars)
<small>N 2021-02-21</small>	$\backslash\textbf{absolutevalue}^*[\langle size \rangle]{\langle quantity \rangle}$	(alias for single bars for fractions)

Semantic aliases. Use  $\backslash\textbf{magnitude}$  or  $\backslash\textbf{magnitude}^*$  to typeset the magnitude of a vector.

$\backslash[ \ \textbf{magnitude}\{\vec{p}\} \ \backslash]$	$\ \boldsymbol{p}\ $
$\backslash[ \ \textbf{magnitude}\{\vec{*p}\} \ \backslash]$	$\ \vec{p}\ $
$\backslash[ \ \textbf{magnitude}^*\{\vec{p}_{\text{final}}\} \ \backslash]$	$\ \boldsymbol{p}_{\text{final}}\ $
$\backslash[ \ \textbf{magnitude}^*\{\vec{*p}_{\text{final}}\} \ \backslash]$	$\ \vec{p}_{\text{final}}\ $

<small>N 2021-04-06</small>	$\backslash\textbf{parallelto}$
<small>N 2021-04-06</small>	$\backslash\textbf{perpendicularto}$

Commands for geometric relationships, mainly intended for subscripts.

$\backslash( \ \vec{F}_{\text{parallelto}} + \vec{F}_{\text{perpendicularto}} \ \backslash)$	$\boldsymbol{F}_{\parallel} + \boldsymbol{F}_{\perp}$
--	---

## 5.2 Problems and Annotated Problem Solutions

N 2021-02-03

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

 (use this variant for vertical lists)  

```
\end{physicsproblem}
```

N 2021-02-03

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

 (use this variant for in-line lists)  

```
\end{physicsproblem*}
```

N 2021-02-03

```
\begin{parts}{\langle title \rangle}
```

 (provides problem parts)  

```
\end{parts}
```

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

N 2012-02-03

**\problempart**

Denotes a part of a problem within a **parts** environment.

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

### Problem 1

This is a physics problem with no parts.

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

### Problem 2

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

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

```

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

```

## Problem 3

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

U 2021-02-26

```

\begin{physicssolution}
  \langle solution steps \rangle

```

(use this variant for numbered steps)

U 2021-02-26

```

\end{physicssolution}
\begin{physicssolution*}
  \langle solution steps \rangle
\end{physicssolution*}

```

(use this variant for unnumbered steps)

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*}

```

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

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

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

$$x = y + z$$

$$z = x - y$$

$$y = x - z$$

U 2012-02-26

```

\reason{\langle reason \rangle}

```

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



```

\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`<sup>P. 56</sup> environment is *only* for mathematical content, not textual content or explanations.

```

\begin{physicsproblem}{Combined Problem and Solution}
  This is an interesting physics problem.
  \begin{physicssolution}
    The solution goes here.
  \end{physicssolution}
\end{physicsproblem}

```

```

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

```

`\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)^{\hilite{2}[circle]} &= \hilite[green]{-}[circle] \\
&\quad (\Delta t)^{\hilite[cyan]{2}[circle]} + \\
&\quad (\Delta x)^{\hilite[orange]{2}[circle]} + \\
&\quad (\Delta y)^{\hilite[blue!50]{2}[circle]} + \\
&\quad (\Delta z)^{\hilite[violet!45]{2}[circle]}
\end{align*}

```

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

```

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

```

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

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

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

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



Figure 1: Image shown 20 percent actual size.

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

Figure 1 is nice. It's captioned [Image shown 20 percent actual size](#) and is on page [59](#).

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

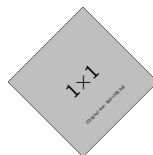


Figure 2: Image shown 20 percent actual size and rotated.

Figure \ref{reffig2} is nice.  
It's captioned \nameref{reffig2} and is on page \pageref{reffig2}.

Figure 2 is nice. It's captioned [Image shown 20 percent actual size and rotated](#) and is on page [59](#).

### 5.3 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.

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

$\boldsymbol{r}$

$r$

$\boldsymbol{r}$

$r$

`\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  $\begin{pmatrix} 1 \\ 0 \end{pmatrix}$  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.

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

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

$C_{1,2}$

`\slot[vector]`

`\slot*[vector]`

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

<code>\( \slot) \)</code>	<code>\)</code>	$(\quad)$
<code>\( \slot[\vec{a}]) \)</code>	<code>\)</code>	$(\underline{a})$
<code>\( \slot* ) \)</code>	<code>\)</code>	$(\quad)$
<code>\( \slot*[\vec{a}]) \)</code>	<code>\)</code>	$(\mathbf{a})$

N 2021-04-06

**\diff**

Intelligent differential (exterior derivative) operator.

<code>\[</code>		$\int x \, dx$
<code>\int x\,,dx</code>		
<code>\]</code>		
<code>\[</code>		$\int x \, dx$
<code>\int x\,,\diff{x}</code>		
<code>\]</code>		
<code>\[</code>		$\int x \, d\mathbf{x}$
<code>\int x\,,\diff*{x}</code>		
<code>\]</code>		

## 5.4 Web VPython and VPython Program Listings

[Web VPython](#)<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.

## 5.5 The `webvpythonblock` Environment

```
\begin{webvpythonblock}[<options>](<link>){<caption>}
<WebVPython code>
\end{webvpythonblock}
```

Code placed here is nicely formatted and optionally linked to its source on [WebVPython.org](https://webvpython.org), which must be in a public (not private) folder. 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 `#` character in a URL should not cause problems.

<sup>3</sup>On November 9, 2021 `GlowScript` was renamed to `Web VPython`. The website was changed to <https://webvpython.org>.

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

```

\begin{webvpythonblock}(tinyurl.com/y3lnqyn3){A \texttt{Web VPython} 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{webvpythonblock}

```

## Web VPython Program 1: A Web VPython 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 deltat = 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 * deltat
41     ball.pos = ball.pos + (pball / mball) * deltat
42     spring.axis = ball.pos - ceiling.pos
43     t = t + deltat
```

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

Web VPython program 1 is nice. It's called [A Web VPython Program](#) and is on page 63.

## 5.6 The `vpythonfile` Command

U 2021-09-17

```
\vpythonfile[<options>](<link>){<file>}{<caption>}
```

Command to load and typeset a VPython program, read from local file *{<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{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 65.

## 5.7 The `webvpythoninline` and `vpythoninline` Commands

U 2021-02-26

U 2021-02-26

```
\webvpythoninline{\<Web VPython code>}
```

```
\vpythoninline{\<VPython code>}
```

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

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

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

## 5.8 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.

```

1 \def\mandistudent@version{3.0.2}
2 \def\mandistudent@date{2021-12-05}
3 \NeedsTeXFormat{LaTeX2e}[2020-02-02]
4 \DeclareRelease{v3.0.2}{2021-12-05}{mandistudent.sty}
5 \DeclareCurrentRelease{v\mandistudent@version}{\mandistudent@date}
6 \ProvidesPackage{mandistudent}
7   [\mandistudent@date\space v\mandistudent@version\space Macros for introductory physics]

  Define a convenient package version command.
8 \newcommand*{\mandistudentversion}{v\mandistudent@version\space dated \mandistudent@date}

  Load third party packages, documenting why each one is needed.
9 \RequirePackage{amsmath}           % AMS goodness (don't load amssymb or amsfonts)
10 \RequirePackage{inline}{enumitem} % needed for physicsproblem environment
11 \RequirePackage{eso-pic}          % needed for \hilite
12 \RequirePackage{g}{esvect}        % needed for nice vector arrow, style g
13 \RequirePackage{pgfplots}         % needed for key-value interface
14 \RequirePackage{iftex}            % needed for requiring LuaLaTeX
15 \RequirePackage{makebox}          % needed for consistent \dirvect; \makebox
16 \RequirePackage{mandi}
17 \RequirePackage{mathtools}        % needed for paired delimiters; extends amsmath
18 \RequirePackage{nicematrix}       % needed for column and row vectors
19 \RequirePackage{most}{tcolorbox}  % needed for program listings
20 \RequirePackage{tensor}           % needed for index notation
21 \RequirePackage{tikz}             % needed for \hilite
22 \usetikzlibrary{shapes,fit,tikzmark} % needed for \hilite
23 \RequirePackage{unicode-math}     % needed for Unicode support

24 \IfFormatAtLeastTF {2020-10-01}  % load xparse if necessary
25   {}%
26   {\RequirePackage{xparse}}%
27 \RequirePackage{hyperref}         % load last
28 \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  $\text{\LaTeX} 2_{\epsilon}$  kernel. Because `unicode-math` is required, all documents using `mandi` must be compiled with an engine that supports Unicode. We recommend `Lua $\text{\LaTeX}$` .

```

29 \unimathsetup{math-style=ISO}
30 \unimathsetup{warnings-off={mathtools-colon,mathtools-overbracket}}

```

Use normal math letters from Latin Modern Math for familiarity with textbooks.

```

31 \setmathfont[Scale=MatchLowercase]
32   {Latin Modern Math} % default math font; better J

```

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

```

33 \setmathfont[Scale=MatchLowercase,range={sf/latin},bfsf/latin]]
34   {TeX Gyre DejaVu Math} % single-storey lowercase g

```

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

```

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

```

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

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

```

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

```

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

```
38 \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.

```
39 \setmathfont[Scale=MatchLowercase,range={"E17C-"E1F6}]{STIX Two Math}
40 \newfontfamily{\symsfgreek}{STIX Two Math}
41 % I don't understand why \text{...} is necessary.
42 \newcommand{\symsfupalpha}      {\text{\symsfgreek{~~~~e196}}}
43 \newcommand{\symsfupbeta}       {\text{\symsfgreek{~~~~e197}}}
44 \newcommand{\symsfupgamma}      {\text{\symsfgreek{~~~~e198}}}
45 \newcommand{\symsfupdelta}      {\text{\symsfgreek{~~~~e199}}}
46 \newcommand{\symsfupepsilon}    {\text{\symsfgreek{~~~~e1af}}}
47 \newcommand{\symsfupvarepsilon} {\text{\symsfgreek{~~~~e19a}}}
48 \newcommand{\symsfupzeta}       {\text{\symsfgreek{~~~~e19b}}}
49 \newcommand{\symsfupeta}        {\text{\symsfgreek{~~~~e19c}}}
50 \newcommand{\symsfuptheta}      {\text{\symsfgreek{~~~~e19d}}}
51 \newcommand{\symsfupvartheta}   {\text{\symsfgreek{~~~~e1b0}}}
52 \newcommand{\symsfupiota}       {\text{\symsfgreek{~~~~e19e}}}
53 \newcommand{\symsfupkappa}      {\text{\symsfgreek{~~~~e19f}}}
54 \newcommand{\symsfuplambda}     {\text{\symsfgreek{~~~~e1a0}}}
55 \newcommand{\symsfupmu}         {\text{\symsfgreek{~~~~e1a1}}}
56 \newcommand{\symsfupnu}         {\text{\symsfgreek{~~~~e1a2}}}
57 \newcommand{\symsfupxi}         {\text{\symsfgreek{~~~~e1a3}}}
58 \newcommand{\symsfupomicron}    {\text{\symsfgreek{~~~~e1a4}}}
59 \newcommand{\symsfuppi}         {\text{\symsfgreek{~~~~e1a5}}}
60 \newcommand{\symsfupvarpi}      {\text{\symsfgreek{~~~~e1b3}}}
61 \newcommand{\symsfuprho}        {\text{\symsfgreek{~~~~e1a6}}}
62 \newcommand{\symsfupvarrho}     {\text{\symsfgreek{~~~~e1b2}}}
63 \newcommand{\symsfupsigma}      {\text{\symsfgreek{~~~~e1a8}}}
64 \newcommand{\symsfupvarsigma}   {\text{\symsfgreek{~~~~e1a7}}}
65 \newcommand{\symsfuptau}        {\text{\symsfgreek{~~~~e1a9}}}
66 \newcommand{\symsfupupsilon}    {\text{\symsfgreek{~~~~e1aa}}}
67 \newcommand{\symsfupphi}        {\text{\symsfgreek{~~~~e1b1}}}
68 \newcommand{\symsfupvarphi}     {\text{\symsfgreek{~~~~e1ab}}}
69 \newcommand{\symsfupchi}        {\text{\symsfgreek{~~~~e1ac}}}
70 \newcommand{\symsfuppsi}        {\text{\symsfgreek{~~~~e1ad}}}
71 \newcommand{\symsfupomega}      {\text{\symsfgreek{~~~~e1ae}}}
72 \newcommand{\symsfupDelta}      {\text{\symsfgreek{~~~~e180}}}
73 \newcommand{\symsfupGamma}      {\text{\symsfgreek{~~~~e17f}}}
74 \newcommand{\symsfupTheta}      {\text{\symsfgreek{~~~~e18e}}}
75 \newcommand{\symsfupLambda}     {\text{\symsfgreek{~~~~e187}}}
76 \newcommand{\symsfupXi}         {\text{\symsfgreek{~~~~e18a}}}
77 \newcommand{\symsfupPi}         {\text{\symsfgreek{~~~~e18c}}}
78 \newcommand{\symsfupSigma}      {\text{\symsfgreek{~~~~e18f}}}
79 \newcommand{\symsfupUpsilon}     {\text{\symsfgreek{~~~~e191}}}
80 \newcommand{\symsfupPhi}        {\text{\symsfgreek{~~~~e192}}}
81 \newcommand{\symsfupPsi}        {\text{\symsfgreek{~~~~e194}}}
82 \newcommand{\symsfupOmega}      {\text{\symsfgreek{~~~~e195}}}
83 \newcommand{\symsfitalpha}      {\text{\symsfgreek{~~~~e1d8}}}
84 \newcommand{\symsfitbeta}       {\text{\symsfgreek{~~~~e1d9}}}
85 \newcommand{\symsfitgamma}      {\text{\symsfgreek{~~~~e1da}}}
86 \newcommand{\symsfitdelta}      {\text{\symsfgreek{~~~~e1db}}}
87 \newcommand{\symsfitepsilon}    {\text{\symsfgreek{~~~~e1f1}}}
88 \newcommand{\symsfitvarepsilon} {\text{\symsfgreek{~~~~e1dc}}}
89 \newcommand{\symsfitzeta}       {\text{\symsfgreek{~~~~e1dd}}}
90 \newcommand{\symsfitaeta}       {\text{\symsfgreek{~~~~e1de}}}
```

```

91 \newcommand{\symsfittheta}    {\text{\symsfgreek{~~~~e1df}}}
92 \newcommand{\symsfitvartheta}{\text{\symsfgreek{~~~~e1f2}}}
93 \newcommand{\symsfitiota}    {\text{\symsfgreek{~~~~e1e0}}}
94 \newcommand{\symsfitkappa}   {\text{\symsfgreek{~~~~e1e1}}}
95 \newcommand{\symsfitlambda}  {\text{\symsfgreek{~~~~e1e2}}}
96 \newcommand{\symsfitmu}      {\text{\symsfgreek{~~~~e1e3}}}
97 \newcommand{\symsfitnu}      {\text{\symsfgreek{~~~~e1e4}}}
98 \newcommand{\symsfitxi}      {\text{\symsfgreek{~~~~e1e5}}}
99 \newcommand{\symsfitomicron} {\text{\symsfgreek{~~~~e1e6}}}
100 \newcommand{\symsfitpi}      {\text{\symsfgreek{~~~~e1e7}}}
101 \newcommand{\symsfitvarpi}   {\text{\symsfgreek{~~~~e1f5}}}
102 \newcommand{\symsfitrho}     {\text{\symsfgreek{~~~~e1e8}}}
103 \newcommand{\symsfitvarrho}  {\text{\symsfgreek{~~~~e1f4}}}
104 \newcommand{\symsfitsigma}   {\text{\symsfgreek{~~~~e1ea}}}
105 \newcommand{\symsfitvarsigma}{\text{\symsfgreek{~~~~e1e9}}}
106 \newcommand{\symsfittau}     {\text{\symsfgreek{~~~~e1eb}}}
107 \newcommand{\symsfitupsilon} {\text{\symsfgreek{~~~~e1ec}}}
108 \newcommand{\symsfitphi}     {\text{\symsfgreek{~~~~e1f3}}}
109 \newcommand{\symsfitvarphi}  {\text{\symsfgreek{~~~~e1ed}}}
110 \newcommand{\symsfitchi}     {\text{\symsfgreek{~~~~e1ee}}}
111 \newcommand{\symsfitpsi}     {\text{\symsfgreek{~~~~e1ef}}}
112 \newcommand{\symsfitomega}   {\text{\symsfgreek{~~~~e1f0}}}
113 \newcommand{\symsfitDelta}   {\text{\symsfgreek{~~~~e1c2}}}
114 \newcommand{\symsfitGamma}   {\text{\symsfgreek{~~~~e1c1}}}
115 \newcommand{\symsfitTheta}   {\text{\symsfgreek{~~~~e1d0}}}
116 \newcommand{\symsfitLambda}  {\text{\symsfgreek{~~~~e1c9}}}
117 \newcommand{\symsfitXi}      {\text{\symsfgreek{~~~~e1cc}}}
118 \newcommand{\symsfitPi}      {\text{\symsfgreek{~~~~e1ce}}}
119 \newcommand{\symsfitSigma}    {\text{\symsfgreek{~~~~e1d1}}}
120 \newcommand{\symsfitUpsilon} {\text{\symsfgreek{~~~~e1d3}}}
121 \newcommand{\symsfitPhi}      {\text{\symsfgreek{~~~~e1d4}}}
122 \newcommand{\symsfitPsi}     {\text{\symsfgreek{~~~~e1d6}}}
123 \newcommand{\symsfitOmega}   {\text{\symsfgreek{~~~~e1d7}}}

```

Tweak the `esvect` package fonts to get the correct font size.

See <https://tex.stackexchange.com/a/566676>.

```

124 \DeclareFontFamily{U}{esvect}{}
125 \DeclareFontShape{U}{esvect}{m}{n}{%
126   <-5.5> vect5
127   <5.5-6.5> vect6
128   <6.5-7.5> vect7
129   <7.5-8.5> vect8
130   <8.5-9.5> vect9
131   <9.5-> vect10
132 }{}%

```

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

```

133 \typeout{}%
134 \typeout{mandistudent: You are using mandistudent \mandistudentversion.}%
135 \typeout{mandistudent: This package requires LuaLaTeX.}%
136 \typeout{mandistudent: This package changes the default math font(s).}%
137 \typeout{mandistudent: This package redefines the \protect\vec\space command.}%
138 \typeout{}%

```

A better, intelligent coordinate-free `\vecP.51` command. Note the use of the `e{~}` type of optional argument. This accounts for much of the flexibility and power of this command. Also note the use of the  $\TeX$  primitives `\sb{}` and `\sp{}`. Why doesn't it work when I put spaces around #3 or #4? Because outside of `\ExplSyntaxOn... \ExplSyntaxOff`, the `_` character has a different catcode and is treated as a mathematical entity.

See <https://tex.stackexchange.com/q/554706/218142>.  
 See also <https://tex.stackexchange.com/a/531037/218142>.

```

139 \RenewDocumentCommand{\vec}{ s m e_{~} }%
140 {%
141   % Note the \, used to make superscript look better.
142   \IfBooleanTF{#1}
143   {%
144     \vv{#2}%          % * gives an arrow
145     % Use \sp{} primitive for superscript.
146     % Adjust superscript for the arrow.
147     \IfValueT{#4}%
148     {\sp{\, #4\vpantom{\smash[t]{\big|}}}}
149   }%
150   {%
151     \sybfit{#2} % no * gives us bold
152     % Use \sp{} primitive for superscript.
153     % No superscript adjustment needed.
154     \IfValueT{#4}%
155     {\sp{#4\vpantom{\smash[t]{\big|}}}}
156   }%
157   % Use \sb{} primitive for subscript.
158   \IfValueT{#3}%
159   {\sb{#3\vpantom{\smash[b]{|}}}}
160 }%

```

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>.

```

161 \NewDocumentCommand{\dirvec}{ s m e_{~} }%
162 {%
163   \widehat%
164   {%
165     \makebox*{\(w\)}%
166     {%
167       \ensuremath{%
168         \IfBooleanTF {#1}%
169         {%
170           #2%
171         }%
172         {%
173           \sybfit{#2}%
174         }%
175       }%
176     }%
177   }%
178   \IfValueT{#3}%
179   {\sb{#3\vpantom{\smash[b]{|}}}}%
180   \IfValueT{#4}%
181   {\sp{\, #4\vpantom{\smash[t]{\big|}}}}%
182 }%

```

The zero vector.

```

183 \NewDocumentCommand{\zerovec}{ s }%
184 {%
185   \IfBooleanTF {#1}
186   {\vv{0}}%
187   {\sybful{0}}%
188 }%

```

Notation for column and row vectors.

See <https://tex.stackexchange.com/a/39054/218142>.

```

189 \ExplSyntaxOn
190 \NewDocumentCommand{\colvec}{ O{,} m }
191 {
192   \__mandi_vectormain:nnnn { p } { \ } { #1 } { #2 }
193 }
194 \NewDocumentCommand{\rowvec}{ O{,} m }
195 {
196   \__mandi_vectormain:nnnn { p } { & } { #1 } { #2 }
197 }
198 \seq_new:N \l__mandi_vectorarg_seq
199 \cs_new_protected:Npn \__mandi_vectormain:nnnn #1#2#3#4
200 {
201   \seq_set_split:Nnn \l__mandi_vectorarg_seq { #3 } { #4 }
202   \begin{#1NiceMatrix}[r]
203     \seq_use:Nnnn \l__mandi_vectorarg_seq { #2 } { #2 } { #2 }
204   \end{#1NiceMatrix}
205 }
206 \ExplSyntaxOff

```

Students always need this symbol.

```

207 \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.

```

208 \DeclarePairedDelimiterX{\doublebars}[1]{\lVert}{\rVert}{\ifblank{#1}{\:\cdot\:{}}{#1}}
209 \DeclarePairedDelimiterX{\singlebars}[1]{\lvert}{\rvert}{\ifblank{#1}{\:\cdot\:{}}{#1}}
210 \DeclarePairedDelimiterX{\anglebrackets}[1]{\langle}{\rangle}{\ifblank{#1}{\:\cdot\:{}}{#1}}
211 \DeclarePairedDelimiterX{\parentheses}[1]{\lparen}{\rparen}{\ifblank{#1}{\:\cdot\:{}}{#1}}
212 \DeclarePairedDelimiterX{\squarebrackets}[1]{\lbrack}{\rbrack}{\ifblank{#1}{\:\cdot\:{}}{#1}}
213 \DeclarePairedDelimiterX{\curlybraces}[1]{\lbrace}{\rbrace}{\ifblank{#1}{\:\cdot\:{}}{#1}}

```

Some semantic aliases. Because of the way [\vec](#)<sup>P.51</sup> and [\dirvec](#)<sup>P.51</sup> are defined, I reluctantly decided not to implement a [\magvec](#) command. It would require accounting for too many options. So [\magnitude](#)<sup>P.54</sup> is the new solution.

```

214 \NewDocumentCommand{\magnitude}{ }{\doublebars}
215 \NewDocumentCommand{\norm}{ }{\doublebars}
216 \NewDocumentCommand{\absolutevalue}{ }{\singlebars}

```

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

```

217 \NewDocumentCommand{\parallelto}{ }%
218 {%
219   \mkern3mu\vphantom{\perp}\vrule depth 0pt\mkern2mu\vrule depth 0pt\mkern3mu%
220 }%
221 \NewDocumentCommand{\perpendicularto}{ }{\perp}

```

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

```

222 \NewDocumentEnvironment{physicsproblem}{ m }%
223 {%
224   \newpage%
225   \section*{#1}%
226   \newlist{parts}{enumerate}{2}%
227   \setlist[parts]{label=\bfseries(\alph*)}%
228 }%
229 {}%
230 \NewDocumentEnvironment{physicsproblem*}{ m }%
231 {%
232   \newpage%

```

```

233 \section*{#1}%
234 \newlist{parts}{enumerate*}{2}%
235 \setlist[parts]{label=\bfseries(\alph*)}%
236 }%
237 {}%
238 \NewDocumentCommand{\problempart}{-}{\item}%

```

An environment for problem solutions.

```

239 \NewDocumentEnvironment{physicssolution}{+b}%
240 {%
241 % Make equation numbering consecutive through the document.
242 \begin{align}
243 #1
244 \end{align}
245 }%
246 {}%
247 \NewDocumentEnvironment{physicssolution*}{+b}%
248 {%
249 % Make equation numbering consecutive through the document.
250 \begin{align*}
251 #1
252 \end{align*}
253 }%
254 {}%

```

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

```

255 \NewDocumentCommand{\reason}{0{4cm} m }%
256 {%
257 &&\begin{minipage}{#1}\raggedright\small #2\end{minipage}%
258 }%

```

Command for highlighting parts of, or entire, mathematical expressions.

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>

```

259 \newcounter{tikzhighlightnode}
260 \NewDocumentCommand{\hilite}{0{magenta!60} m 0{rectangle} }%
261 {%
262 \stepcounter{tikzhighlightnode}%
263 \tikzmarknode{highlighted-node-\number\value{tikzhighlightnode}}{#2}%
264 \edef\temp{%
265 \noexpand\AddToShipoutPictureBG{%
266 \noexpand\begin{tikzpicture}[overlay,remember picture]%
267 \noexpand\iftikzmarkconcurrentpage{highlighted-node-\number\value{tikzhighlightnode}}%
268 \noexpand\node[inner sep=1.0pt,fill=#1,#3,fit=(highlighted-node-\number\value{tikzhighlightnode})]{};%
269 \noexpand\fi
270 \noexpand\end{tikzpicture}%
271 }%
272 }%
273 \temp%
274 }%

```

A simplified command for importing images.

See <https://tex.stackexchange.com/a/614478/218142>.



```

275 \NewDocumentCommand{\image}{ O{scale=1} m m m }%
276 {%
277   \par
278   \begin{figure}[ht!]
279     \centering%
280     \includegraphics[#1]{#2}%
281     \caption{#3}%
282     \label{#4}%
283   \end{figure}%
284   \par
285 }%

```

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.

```

286 \NewDocumentCommand{\veccomp}{ s m }%
287 {%
288   % Consider renaming this to \vectorsym.
289   \IfBooleanTF{#1}
290   {%
291     \symnormal{#2}%
292   }%
293   {%
294     \symbfit{#2}%
295   }%
296 }%
297 \NewDocumentCommand{\tencomp}{ s m }%
298 {%
299   % Consider renaming this to \tensororsym.
300   \IfBooleanTF{#1}%
301   {%
302     \symsfit{#2}%
303   }%
304   {%
305     \symbfsfit{#2}%
306   }%
307 }%

```

Command to typeset tensor valence.

```

308 \NewDocumentCommand{\valence}{ s m m }%
309 {%
310   \IfBooleanTF{#1}%
311   {%
312     (#2,#3)%
313   }%
314   {%
315     \binom{#2}{#3}%
316   }%
317 }%

```

Intelligent notation for contraction on pairs of slots.

```

318 \NewDocumentCommand{\contraction}{ s m }%
319 {%
320   \IfBooleanTF{#1}
321   {%
322     \mathsf{C}%
323   }%
324   {%
325     \sybbb{C}%
326   }%

```

```

327   _{#2}
328 }%

```

Intelligent slot command for coordinate-free tensor notation.

```

329 \NewDocumentCommand{\slot}{ s d[] }%
330 {%
331   % d[] must be used because of the way consecutive optional
332   % arguments are handled. See xparse docs for details.
333   \IfBooleanTF{#1}
334   {%
335     \IfValueTF{#2}
336     {% Insert a vector, but don't show the slot.
337       \smash{\makebox[1.5em]{\ensuremath{#2}}}
338     }%
339     {% No vector, no slot.
340       \smash{\makebox[1.5em]{\ensuremath{}}}
341     }%
342   }%
343   {%
344     \IfValueTF{#2}
345     {% Insert a vector and show the slot.
346       \underline{\smash{\makebox[1.5em]{\ensuremath{#2}}}}
347     }%
348     {% No vector; just show the slot.
349       \underline{\smash{\makebox[1.5em]{\ensuremath{}}}}
350     }%
351   }%
352 }%

```

Intelligent differential (exterior derivative) operator.

```

353 \NewDocumentCommand{\diff}{ s }%
354 {%
355   \mathop{\!}%
356   \IfBooleanTF{#1}%
357   {%
358     \symsfsfup{d}%
359   }%
360   {%
361     \symsfup{d}%
362   }%
363 }%

```

Here is a clever way to color digits in program listings thanks to Ulrike Fischer.

See <https://tex.stackexchange.com/a/570717/218142>.

```

364 \directlua{%
365   luaotfload.add_colorscheme("colordigits",
366     [{"8000FF"} = {"one","two","three","four","five","six","seven","eight","nine","zero"}])
367 }%
368 \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 `tclobox`.

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

```

369 \newfontfamily\gsfontfamily{DejaVuSansMono} % new font for listings
370 \definecolor{gsbggray}{rgb}{0.90,0.90,0.90} % background gray
371 \definecolor{gsgray}{rgb}{0.30,0.30,0.30} % gray
372 \definecolor{gsgreen}{rgb}{0.00,0.60,0.00} % green
373 \definecolor{gsorange}{rgb}{0.80,0.45,0.12} % orange
374 \definecolor{gspeach}{rgb}{1.00,0.90,0.71} % peach

```

```

375 \definecolor{gspearl}      {rgb}{0.94,0.92,0.84} % pearl
376 \definecolor{gsplum}      {rgb}{0.74,0.46,0.70} % plum
377 \lstdefinestyle{vpython}%
378 {%                                % style for listings
379     backgroundcolor=\color{gsbggray},%    % background color
380     basicstyle=\colordigits\footnotesize,% % default style
381     breakatwhitespace=true%              % break at whitespace
382     breaklines=true,%                    % break long lines
383     captionpos=b,%                       % position caption
384     classoffset=1,%                      % STILL DON'T UNDERSTAND THIS
385     commentstyle=\color{gsgray},%        % font for comments
386     deletekeywords={print},%             % delete keywords from the given language
387     emph={self,cls,@classmethod,@property},% % words to emphasize
388     emphstyle=\color{gsorange}\itshape,% % font for emphasis
389     escapeinside={(*@){@*}},%           % add LaTeX within your code
390     frame=tb,%                           % frame style
391     framerule=2.0pt,%                     % frame thickness
392     framexleftmargin=5pt,%                % extra frame left margin
393     %identifierstyle=\sfamily,%           % style for identifiers
394     keywordstyle=\gsfontfamily\color{gsplum},% % color for keywords
395     language=Python,%                    % select language
396     linewidth=\linewidth,%              % width of listings
397     morekeywords={%                      % VPython/Web VPython specific keywords
398         __future__,abs,acos,align,ambient,angle,append,append_to_caption,%
399         append_to_title,arange,arrow,asin,astuple,atan,atan2,attach_arrow,%
400         attach_trail,autoscale,axis,background,billboard,bind,black,blue,border,%
401         bounding_box,box,bumpaxis,bumpmap,bumpmaps,camera,canvas,caption,capture,%
402         ceil,center,clear,clear_trail,click,clone,CoffeeScript,coils,color,combin,%
403         comp,compound,cone,convex,cos,cross,curve,cyan,cylinder,data,degrees,del,%
404         delete,depth,descender,diff_angle,digits,division,dot,draw_complete,%
405         ellipsoid,emissive,end_face_color,equal,explog,extrusion,faces,factorial,%
406         False,floor,follow,font,format,forward,fov,frame,gcurve,gdisplay,gdots,%
407         get_library,get_selected,ghbars,global,GlowScript,graph,graphs,green,gvbars,%
408         hat,headlength,headwidth,height,helix,hsv_to_rgb,index,interval,keydown,%
409         keyup,label,length,lights,line,linicolor,linewidth,logx,logy,lower_left,%
410         lower_right,mag,mag2,magenta,make_trail,marker_color,markers,material,%
411         max,min,mouse,mousedown,mousemove,mouseup,newball,norm,normal,objects,%
412         offset,one,opacity,orange,origin,path,pause,pi,pixel_to_world,pixels,plot,%
413         points,pos,pow,pps,print,print_function,print_options,proj,purple,pyramid,%
414         quad,radians,radius,random,rate,ray,read_local_file,readonly,red,redraw,%
415         retain,rgb_to_hsv,ring,rotate,round,scene,scroll,shaftwidth,shape,shapes,%
416         shininess,show_end_face,show_start_face,sign,sin,size,size_units,sleep,%
417         smooth,space,sphere,sqrt,start,start_face_color,stop,tan,text,textpos,%
418         texture,textures,thickness,title,trail_color,trail_object,trail_radius,%
419         trail_type,triangle,trigger,True,twist,unbind,up,upper_left,upper_right,%
420         userpan,userspin,userzoom,vec,vector,vertex,vertical_spacing,visible,%
421         visual,vpython,VPython,waitfor,WebVPython,white,width,world,xtitle,%
422         yellow,yoffset,ytitle%
423     },%
424     morekeywords={print,None,TypeError},% % additional keywords
425     morestring=[b]{"""},%               % treat triple quotes as strings
426     numbers=left,%                      % where to put line numbers
427     numbersep=10pt,%                    % how far line numbers are from code
428     numberstyle=\bfseries\tiny,%        % set to 'none' for no line numbers
429     showstringspaces=false,%            % show spaces in strings
430     showtabs=false,%                    % show tabs within strings
431     stringstyle=\gsfontfamily\color{gsgreen},% % color for strings
432     upquote=true,%                      % how to typeset quotes
433 }%

```

Introduce a new, more intelligent `webvpythonblock`<sup>→P.61</sup> environment.  
 See <https://tex.stackexchange.com/a/232208/218142>.

```

434 \AtBeginEnvironment{webvpythonblock}{\catcode`\#=12}
435 \AtEndEnvironment{webvpythonblock}{\catcode`\#=6}
436 \NewTCBListing[auto counter,list inside=gsprogs]{webvpythonblock}{0}{D(){webvpython.org} m }%
437 {%
438   breakable,%
439   center,%
440   code = \newpage,%
441   %derivpeach,%
442   enhanced,%
443   hyperurl interior = https://#2,%
444   label = {gs:\thetcbcounter},%
445   left = 8mm,%
446   list entry = \thetcbcounter~~~~~#3,%
447   listing only,%
448   listing style = vpython,%
449   nameref = {#3},%
450   title = \texttt{Web VPython} Program \thetcbcounter: #3,%
451   width = 0.9\textwidth,%
452   {#1},
453 }%

```

A new command for generating a list of Web VPython programs.

```

454 \NewDocumentCommand{\listofwebvpythonprograms}{}%
455 {%
456   \tcblistof[\section*]{gsprogs}{List of \texttt{Web VPython} Programs}%
457 }%

```

Introduce a new, more intelligent `\vpythonfile`<sup>→P.64</sup> command.  
 See <https://tex.stackexchange.com/q/616205/218142>.

```

458 \newcommand*{\vpythonfile}{\catcode`\#=12 \vpythonfile@auxA}
459 \NewDocumentCommand{\vpythonfile@auxA}{0}{D(){webvpython.org} m m }%
460 {%
461   \vpythonfile@auxB[#1](#2){#3}{#4}%
462   \catcode`\#=6
463 }%
464 \NewTCBInputListing[auto counter,list inside=vpprogs]{\vpythonfile@auxB}{0}{D(){vpython.org} m m }%
465 {%
466   breakable,%
467   center,%
468   code = \newpage,%
469   %derivgray,%
470   enhanced,%
471   hyperurl interior = https://#2,%
472   label = {vp:\thetcbcounter},%
473   left = 8mm,%
474   list entry = \thetcbcounter~~~~~#4,%
475   listing file = {#3},%
476   listing only,%
477   listing style = vpython,%
478   nameref = {#4},%
479   title = \texttt{VPython} Program \thetcbcounter: #4,%
480   width = 0.9\textwidth,%
481   {#1},%
482 }%

```

A new command for generating a list of VPython programs.

```

483 \NewDocumentCommand{\listofvpythonprograms}{}%
484 {%
485   \tblistof[\section*]{vpprogs}{List of \texttt{VPython} Programs}%
486 }%

```

Introduce a new `\webvpythoninline`<sup>P.66</sup> command.

```

487 \DeclareTotalTCBox{\webvpythoninline}{ m }%
488 {%
489   bottom = 0pt,%
490   bottomrule = 0.0mm,%
491   boxsep = 1.0mm,%
492   colback = gsbggray,%
493   colframe = gsbggray,%
494   left = 0pt,%
495   leftrule = 0.0mm,%
496   nobeforeafter,%
497   right = 0pt,%
498   rightrule = 0.0mm,%
499   sharp corners,%
500   tcbox raise base,%
501   top = 0pt,%
502   toprule = 0.0mm,%
503 }%
504 {\lstinline[style = vpython]{#1}}%

```

Define `\vpythoninline`<sup>P.66</sup>, a semantic alias for VPython in-line listings.

```

505 \NewDocumentCommand{\vpythoninline}{\}{\webvpythoninline}%

```

## 6 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 that text. Note that `mandiexp` requires, and loads, `mandi` but `mandi` doesn't require, and doesn't load, `mandiexp`.

Load `mandiexp` as you would any package in your preamble. There are no package options.

```
\usepackage{mandiexp}
```

```
\mandiexpversion
```

Typesets the current version and build date.

The version is `\mandiexpversion` and is a stable build.

The version is v3.0.2 dated 2021-12-05 and is a stable build.

### 6.1 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.

---

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

```

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

```

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

<code>\lhsenergyprinciple</code>	(LHS of delta form)
<code>\rhsenergyprinciple[⟨+process...⟩]</code>	(RHS of delta form)
<code>\lhsenergyprincipleupdate</code>	(LHS of update form)
<code>\rhsenergyprincipleupdate[⟨+process...⟩]</code>	(RHS of update form)
<code>\energyprinciple[⟨+process...⟩]</code>	(delta form)
<code>\energyprincipleupdate[⟨+process...⟩]</code>	(update form)

Variants of command for typesetting the energy principle.

```

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

```

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

<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 angular momentum principle. Use starred variants to get arrow notation for vectors.

<code>\( \lhsangularmomentumprinciple \)</code>	<code>\)</code>	$\Delta L_{A,\text{sys},\text{net}}$
<code>\( \rhsangularmomentumprinciple \)</code>	<code>\)</code>	$\tau_{A,\text{sys},\text{net}} \Delta t$
<code>\( \lhsangularmomentumprincipleupdate \)</code>	<code>\)</code>	$L_{A,\text{sys},\text{final}}$
<code>\( \rhsangularmomentumprincipleupdate \)</code>	<code>\)</code>	$L_{A,\text{sys},\text{initial}} + \tau_{A,\text{sys},\text{net}} \Delta t$
<code>\( \angularmomentumprinciple \)</code>	<code>\)</code>	$\Delta L_{A,\text{sys},\text{net}} = \tau_{A,\text{sys},\text{net}} \Delta t$
<code>\( \angularmomentumprincipleupdate \)</code>	<code>\)</code>	$L_{A,\text{sys},\text{final}} = L_{A,\text{sys},\text{initial}} + \tau_{A,\text{sys},\text{net}} \Delta t$
<code>\( \lhsangularmomentumprinciple* \)</code>	<code>\)</code>	$\Delta \vec{L}_{A,\text{sys},\text{net}}$
<code>\( \rhsangularmomentumprinciple* \)</code>	<code>\)</code>	$\vec{\tau}_{A,\text{sys},\text{net}} \Delta t$
<code>\( \lhsangularmomentumprincipleupdate* \)</code>	<code>\)</code>	$\vec{L}_{A,\text{sys},\text{final}}$
<code>\( \rhsangularmomentumprincipleupdate* \)</code>	<code>\)</code>	$\vec{L}_{A,\text{sys},\text{initial}} + \vec{\tau}_{A,\text{sys},\text{net}} \Delta t$
<code>\( \angularmomentumprinciple* \)</code>	<code>\)</code>	$\Delta \vec{L}_{A,\text{sys},\text{net}} = \vec{\tau}_{A,\text{sys},\text{net}} \Delta t$
<code>\( \angularmomentumprincipleupdate* \)</code>	<code>\)</code>	$\vec{L}_{A,\text{sys},\text{final}} = \vec{L}_{A,\text{sys},\text{initial}} + \vec{\tau}_{A,\text{sys},\text{net}} \Delta t$

## 6.2 Other Expressions

N 2021-02-13

`\energyof{<label>}[<label>]`

Generic symbol for the energy of some entity.

<code>\( \energyof{\symup{electron}} \)</code>	<code>\)</code>	$E_{\text{electron}}$
<code>\( \energyof{\symup{electron}}[\symup{final}] \)</code>	<code>\)</code>	$E_{\text{electron},\text{final}}$

N 2021-02-13

`\systemenergy[<label>]`

Symbol for system energy.

<code>\( \systemenergy \)</code>	<code>\)</code>	$E_{\text{sys}}$
<code>\( \systemenergy[\symup{final}] \)</code>	<code>\)</code>	$E_{\text{sys},\text{final}}$

N 2021-02-13

`\particleenergy[<label>]`

Symbol for particle energy.

<code>\( \particleenergy \)</code>	<code>\)</code>	$E_{\text{particle}}$
<code>\( \particleenergy[\symup{final}] \)</code>	<code>\)</code>	$E_{\text{particle},\text{final}}$

N 2021-02-13

`\restenergy[<label>]`

Symbol for rest energy.

<code>\( \restenergy \)</code>	<code>\)</code>	$E_{\text{rest}}$
<code>\( \restenergy[\symup{final}] \)</code>	<code>\)</code>	$E_{\text{rest},\text{final}}$



N 2021-02-13

`\internalenergy[⟨label⟩]`

Symbol for internal energy.

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

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

N 2021-02-13

`\chemicalenergy[⟨label⟩]`

Symbol for chemical energy.

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

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

N 2021-02-13

`\thermalenergy[⟨label⟩]`

Symbol for thermal energy.

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

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

N 2021-02-13

`\photonenergy[⟨label⟩]`

Symbol for photon energy.

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

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

N 2021-02-13

`\translationalkineticenergy[⟨label⟩]`

N 2021-02-13

`\translationalkineticenergy*[⟨label⟩]`

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

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

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

N 2021-02-13

`\rotationalkineticenergy[⟨label⟩]`

N 2021-02-13

`\rotationalkineticenergy*[⟨label⟩]`

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  
N 2021-02-13

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

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

<code>\( \vibrationalkineticenergy \)</code>	<code>\)</code>	$K_{\text{vib}}$
<code>\( \vibrationalkineticenergy[\symup{initial}] \)</code>	<code>\)</code>	$K_{\text{vib,initial}}$
<code>\( \vibrationalkineticenergy* \)</code>	<code>\)</code>	$E_{\text{vib}}$
<code>\( \vibrationalkineticenergy*[\symup{initial}] \)</code>	<code>\)</code>	$E_{\text{vib,initial}}$

N 2021-02-13

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

Symbol for gravitational potential energy.

<code>\( \gravitationalpotentialenergy \)</code>	<code>\)</code>	$U_{\text{g}}$
<code>\( \gravitationalpotentialenergy[\symup{final}] \)</code>	<code>\)</code>	$U_{\text{g,final}}$

N 2021-02-13

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

Symbol for electric potential energy.

<code>\( \electricpotentialenergy \)</code>	<code>\)</code>	$U_{\text{e}}$
<code>\( \electricpotentialenergy[\symup{final}] \)</code>	<code>\)</code>	$U_{\text{e,final}}$

N 2021-02-13

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

Symbol for spring potential energy.

<code>\( \springpotentialenergy \)</code>	<code>\)</code>	$U_{\text{s}}$
<code>\( \springpotentialenergy[\symup{final}] \)</code>	<code>\)</code>	$U_{\text{s,final}}$

### 6.3 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.

```

1 \def\mandiexp@version{3.0.2}
2 \def\mandiexp@date{2021-12-05}
3 \NeedsTeXFormat{LaTeX2e}[2020-02-02]
4 \DeclareRelease{v3.0.2}{2021-12-05}{mandiexp.sty}
5 \DeclareCurrentRelease{v\mandiexp@version}{\mandiexp@date}
6 \ProvidesPackage{mandiexp}
7 [\mandiexp@date\space v\mandiexp@version\space Macros for Matter & Interactions]

```

Define a convenient package version command.

```

8 \newcommand*{\mandiexpversion}{v\mandiexp@version\space dated \mandiexp@date}
9 \RequirePackage{mandi}

10 \IfFormatAtLeastTF {2020-10-01} % load xparse if necessary
11 {}%
12 {\RequirePackage{xparse}}%

13 \typeout{}%
14 \typeout{mandiexp: You are using mandiexp \mandiexpversion.}
15 \typeout{mandiexp: This package requires LuaLaTeX.}%
16 \typeout{}%
17 %
18 % Commands specific to Matter & Interactions
19 % The momentum principle
20 \NewDocumentCommand{\lhsmomentumprinciple}{ s }%
21 {%
22   \Delta
23   \IfBooleanTF{#1}%
24   {%
25     \vec*{p}
26   }%
27   {%
28     \vec{p}%
29   }%
30   \sb{\symup{sys}}}%
31 }%
32 \NewDocumentCommand{\rhsmomentumprinciple}{ s }%
33 {%
34   \IfBooleanTF{#1}%
35   {%
36     \vec*{F}%
37   }%
38   {%
39     \vec{F}%
40   }%
41   \sb{\symup{sys,net}}\,\Delta t%
42 }%
43 \NewDocumentCommand{\lhsmomentumprincipleupdate}{ s }%
44 {%
45   \IfBooleanTF{#1}%
46   {%
47     \vec*{p}%
48   }%
49   {%
50     \vec{p}%

```

```

51     }%
52     \sb{\symup{sys,final}}}%
53 }%
54 \NewDocumentCommand{\rhsmomentumprincipleupdate}{ s }%
55 {%
56     \IfBooleanTF{#1}%
57     {%
58         \vec*{p}%
59     }%
60     {%
61         \vec{p}%
62     }%
63     \sb{\symup{sys,initial}}+%
64     \IfBooleanTF{#1}%
65     {%
66         \vec*{F}%
67     }%
68     {%
69         \vec{F}%
70     }%
71     \sb{\symup{sys,net}}\,\Delta t%
72 }%
73 \NewDocumentCommand{\momentumprinciple}{ s }%
74 {%
75     \IfBooleanTF{#1}%
76     {%
77         \lhsmomentumprinciple* = \rhsmomentumprinciple*%
78     }%
79     {%
80         \lhsmomentumprinciple = \rhsmomentumprinciple%
81     }%
82 }%
83 \NewDocumentCommand{\momentumprincipleupdate}{ s }%
84 {%
85     \IfBooleanTF{#1}%
86     {%
87         \lhsmomentumprincipleupdate* = \rhsmomentumprincipleupdate*%
88     }%
89     {%
90         \lhsmomentumprincipleupdate = \rhsmomentumprincipleupdate%
91     }%
92 }%
93 % The momentum principle
94 \NewDocumentCommand{\lhsenergyprinciple}{}%
95 {%
96     \Delta E_{\symup{sys}}%
97 }%
98 \NewDocumentCommand{\rhsenergyprinciple}{ 0{ } }%
99 {%
100     W_{\symup{ext}}#1%
101 }%
102 \NewDocumentCommand{\lhsenergyprincipleupdate}{}%
103 {%
104     E_{\symup{sys,final}}%
105 }%
106 \NewDocumentCommand{\rhsenergyprincipleupdate}{ 0{ } }%
107 {%
108     E_{\symup{sys,initial}}+%
109     W_{\symup{ext}}#1%

```

```

110 }%
111 \NewDocumentCommand{\energyprinciple}{ 0{ } }%
112 {%
113   \lhsenergyprinciple = \rhsenergyprinciple[#1]%
114 }%
115 \NewDocumentCommand{\energyprincipleupdate}{ 0{ } }%
116 {%
117   \lhsenergyprincipleupdate = \rhsenergyprincipleupdate[#1]%
118 }%
119 % The angular momentum principle
120 \NewDocumentCommand{\hsangularmomentumprinciple}{ s }%
121 {%
122   \Delta%
123   \IfBooleanTF{#1}%
124   {%
125     \vec*{L}%
126   }%
127   {%
128     \vec{L}%
129   }%
130   \sb{A\symup{,sys,net}}%
131 }%
132 \NewDocumentCommand{\rhsangularmomentumprinciple}{ s }%
133 {%
134   \IfBooleanTF{#1}%
135   {%
136     \vec*{\tau}%
137   }%
138   {%
139     \vec{\tau}%
140   }%
141   \sb{A\symup{,sys,net}}\,\Delta t%
142 }%
143 \NewDocumentCommand{\lhsangularmomentumprincipleupdate}{ s }%
144 {%
145   \IfBooleanTF{#1}%
146   {%
147     \vec*{L}%
148   }%
149   {%
150     \vec{L}%
151   }%
152   \sb{A,\symup{sys,final}}%
153 }%
154 \NewDocumentCommand{\rhsangularmomentumprincipleupdate}{ s }%
155 {%
156   \IfBooleanTF{#1}%
157   {%
158     \vec*{L}%
159   }%
160   {%
161     \vec{L}%
162   }%
163   \sb{A\symup{,sys,initial}}+%
164   \IfBooleanTF{#1}%
165   {%
166     \vec*{\tau}%
167   }%
168   {%

```

```

169      \vec{\tau}%
170    }%
171    \sb{A\symup{sys,net}}\,\Delta t%
172  }%
173 \NewDocumentCommand{\angularmomentumprinciple}{ s }%
174 {%
175   \IfBooleanTF{#1}%
176   {%
177     \lhsangularmomentumprinciple* = \rhsangularmomentumprinciple*%
178   }%
179   {%
180     \lhsangularmomentumprinciple = \rhsangularmomentumprinciple%
181   }%
182 }%
183 \NewDocumentCommand{\angularmomentumprincipleupdate}{ s }%
184 {%
185   \IfBooleanTF{#1}%
186   {%
187     \lhsangularmomentumprincipleupdate* = \rhsangularmomentumprincipleupdate*%
188   }%
189   {%
190     \lhsangularmomentumprincipleupdate = \rhsangularmomentumprincipleupdate%
191   }%
192 }%
193 \NewDocumentCommand{\energyof}{ m o }%
194 {%
195   E_{#1%
196     \IfValueT{#2}%
197     {,#2}%
198   }%
199 }%
200 \NewDocumentCommand{\systemenergy}{ o }%
201 {%
202   E_{\symup{sys}%
203     \IfValueT{#1}%
204     {,#1}%
205   }%
206 }%
207 \NewDocumentCommand{\particleenergy}{ o }%
208 {%
209   E_{\symup{particle}%
210     \IfValueT{#1}%
211     {,#1}%
212   }%
213 }%
214 \NewDocumentCommand{\restenergy}{ o }%
215 {%
216   E_{\symup{rest}%
217     \IfValueT{#1}%
218     {,#1}%
219   }%
220 }%
221 \NewDocumentCommand{\internalenergy}{ o }%
222 {%
223   E_{\symup{internal}%
224     \IfValueT{#1}%
225     {,#1}%
226   }%
227 }%

```

```

228 \NewDocumentCommand{\chemicalenergy}{ o }%
229 {%
230     E_{\symup{chem}}%
231     \IfValueT{#1}%
232     {,#1}%
233 }%
234 }%
235 \NewDocumentCommand{\thermalenergy}{ o }%
236 {%
237     E_{\symup{therm}}%
238     \IfValueT{#1}%
239     {,#1}%
240 }%
241 }%
242 \NewDocumentCommand{\photonenergy}{ o }%
243 {%
244     E_{\symup{photon}}%
245     \IfValueT{#1}%
246     {,#1}%
247 }%
248 }%
249 \NewDocumentCommand{\translationalkineticenergy}{ s d[] }%
250 {%
251     % d[] must be used because of the way consecutive optional
252     % arguments are handled. See xparse docs for details.
253     % See https://tex.stackexchange.com/a/569011/218142
254     \IfBooleanTF{#1}%
255     {%
256         E_{\bgroup \symup{K}}%
257     }%
258     {%
259         K_{\bgroup \symup{trans}}%
260     }%
261         \IfValueT{#2}{,#2}%
262         \egroup%
263 }%
264 \NewDocumentCommand{\rotationalkineticenergy}{ s d[] }%
265 {%
266     % d[] must be used because of the way consecutive optional
267     % arguments are handled. See xparse docs for details.
268     % See https://tex.stackexchange.com/a/569011/218142
269     \IfBooleanTF{#1}%
270     {%
271         E_{\bgroup}%
272     }%
273     {%
274         K_{\bgroup}%
275     }%
276         \symup{rot}\IfValueT{#2}{,#2}%
277         \egroup%
278 }%
279 \NewDocumentCommand{\vibrationalkineticenergy}{ s d[] }%
280 {%
281     % d[] must be used because of the way consecutive optional
282     % arguments are handled. See xparse docs for details.
283     % See https://tex.stackexchange.com/a/569011/218142
284     \IfBooleanTF{#1}%
285     {%
286         E_{\bgroup}%

```

```

287     }%
288     {%
289         K_\bgroup%
290     }%
291         \symup{vib}\IfValueT{#2}{, #2}%
292     \egroup%
293 }%
294 \NewDocumentCommand{\gravitationalpotentialenergy}{ o }%
295 {%
296     U_{\symup{g}%
297         \IfValueT{#1}%
298         {, #1}%
299     }%
300 }%
301 \NewDocumentCommand{\electricpotentialenergy}{ o }%
302 {%
303     U_{\symup{e}%
304         \IfValueT{#1}%
305         {, #1}%
306     }%
307 }%
308 \NewDocumentCommand{\springpotentialenergy}{ o }%
309 {%
310     U_{\symup{s}%
311         \IfValueT{#1}%
312         {, #1}%
313     }%
314 }%

```



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