The mandi Bundle

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mandi version v3.0.0 dated 2021-08-21
mandistudent version v3.0.0 dated 2021-08-21
mandiexp version v3.0.0 dated 2021-08-21

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Acknowledgements

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

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

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1   Introduction

The mandi[1] 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. 54} provides other typesetting capability appropriate for written problem solutions. Finally, package mandiexp^{→ P. 80} provides commands for typesetting expressions from *Matter & Interactions*[2]

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 LuaLaTeX. 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, expecially new users, will have a relatively recent TeX distribution (like TeX Live) that includes a recently updated LaTeX kernel. If users report that this is a major problem, I can provide some degree of backwards compatibility.

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[1] The bundle name can be pronounced either with two syllables, to rhyme with *candy*, or with three syllables, as *M and I*.
[2] See *Matter & Interactions* and https://matterandinteractions.org/ for details.

2 Student/Instructor Quick Guide

Use $\backslash\text{vec}^{\to\,\text{P.}\,54}$ to typeset the symbol for a vector. Use $\backslash\text{magnitude}^{\to\,\text{P.}\,57}$ to typeset the symbol for a vector's magnitude. Use $\backslash\text{dirvec}^{\to\,\text{P.}\,54}$ to typeset the symbol for a vector's direction. Use $\backslash\text{changein}^{\to\,\text{P.}\,55}$ to typeset the symbol for the change in a vector or scalar. Use $\backslash\text{zerovec}^{\to\,\text{P.}\,55}$ to typeset the zero vector. Use $\backslash\text{timestento}^{\to\,\text{P.}\,36}$ to typeset scientific notation.

`\( \vec{p} \) or \( \vec*{p} \)` `\\`	$\boldsymbol{p}$ or $\vec{p}$
`\( \vec{p}_{\symup{final}} \) or \( \vec*{p}_{\symup{final}} \)` `\\`	$\boldsymbol{p}_{\text{final}}$ or $\vec{p}_{\text{final}}$
`\( \magnitude{\vec{p}} \) or \( \magnitude*{\vec{p}_{\symup{final}}} \)` `\\`	$\|\boldsymbol{p}\|$ or $\|\boldsymbol{p}_{\text{final}}\|$
`\( \dirvec{p} \) or \( \dirvec*{p} \)` `\\`	$\widehat{\boldsymbol{p}}$ or $\widehat{p}$
`\( \changein \vec{p} \) or \( \changein t \)` `\\`	$\Delta\boldsymbol{p}$ or Δt
`\( \zerovec \) or \( \zerovec* \)` `\\`	$\mathbf{0}$ or $\vec{0}$
`\( 6.02\timestento{-19} \)`	6.02×10^{-19}

Use a physical quantity's$^{\to\ \text{P.}\,9}$ name to typeset a magnitude and that quantity's units. If the quantity is a vector, you can add `vector` either to the beginning or the end of the quantity's name. For example, if you want momentum, use $\backslash\text{momentum}^{\to\,\text{P.}\,9}$ and its variants.

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

Use a physical constant's$^{\to\ \text{P.}\,25}$ name to typeset its numerical value and units. Append `mathsymbol` to the constant's name to get its mathematical symbol. For example, if you want to typeset the vacuum permittivity, use $\backslash\text{vacuumpermittivity}^{\to\,\text{P.}\,33}$ and its variant.

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

Use $\backslash\text{mivector}^{\to\,\text{P.}\,37}$ to typeset symbolic vectors with components. Use the aliases $\backslash\text{direction}^{\to\,\text{P.}\,13}$ to typeset a direction or unit vector.

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

$\left\langle \underline{\quad},\underline{\quad},\underline{\quad}\right\rangle$ or $\langle p_x, p_y, p_z\rangle$

$\frac{1}{\sqrt{3}}, \frac{1}{\sqrt{3}}, \frac{1}{\sqrt{3}}$ or

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

3 The **mandi** Package

Load mandi as you would any package in your preamble.

```
\usepackage[options]{mandi}
```

\mandiversion

  Typesets the current version and build date.

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

The version is v3.0.0 dated 2021-08-21 and is a stable build.

3.1 Package Options

N 2021-01-30 **units**=⟨*type of unit*⟩   (initially unspecified, set to **alternate**)
N 2021-01-30 **preciseconstants**=⟨*boolean*⟩   (initially unspecified, set to **false**)

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

3.2 The **mandisetup** Command

N 2021-02-17 **\mandisetup**{⟨*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.

```
\mandisetup{units=base}
```

```
\mandisetup{preciseconstants}
```

```
\mandisetup{preciseconstants=false}
```

3.3 LuaLATEX is Required

In order to make use of better fonts and Unicode features, mandi now requires the LuaLATEX engine for processing documents. It will not work with other engines.

3.4 Physical Quantities

3.4.1 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{$\langle c_1, \ldots, c_n \rangle$}
\vectormomentum{$\langle c_1, \ldots, c_n \rangle$}

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

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

Commands that include the name of a physical quantity typeset units, so they shouldn't be used for algebraic or symbolic values of components. For example, one shouldn't use \vectormomentum{mv_x,mv_y,mv_z} but instead the generic \mivector{mv_x,mv_y,mv_z} instead.

3.4.2 Checking Physical Quantities

\checkquantity{⟨*name*⟩}

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

3.4.3 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`. Rememeber that units are not present with symbolic (algebraic) quantities, so do not use the `\vector` variants of these commands for symbolic components. Use `\mivector`$^{\rightarrow\,\mathrm{P.\,37}}$ instead.

\acceleration{⟨*magnitude*⟩}
\accelerationvector{⟨$c_1, \ldots, c_n$⟩}
\vectoracceleration{⟨$c_1, \ldots, c_n$⟩}

name
\acceleration

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

\amount{⟨*magnitude*⟩}

name
\amount

base	derived	alternate
mol	mol	mol

\angularacceleration{⟨*magnitude*⟩}
\angularaccelerationvector{⟨$c_1, \ldots, c_n$⟩}
\vectorangularacceleration{⟨$c_1, \ldots, c_n$⟩}

name
\angularacceleration

base	derived	alternate
$\mathrm{rad} \cdot \mathrm{s}^{-2}$	$\mathrm{rad/s}^2$	$\mathrm{rad/s}^2$

\angularfrequency{⟨*magnitude*⟩}

name
\angularfrequency

base	derived	alternate
$\mathrm{rad} \cdot \mathrm{s}^{-1}$	rad/s	rad/s

`\angularimpulse{⟨magnitude⟩}`
`\angularimpulsevector{⟨c_1, ..., c_n⟩}`
`\vectorangularimpulse{⟨c_1, ..., c_n⟩}`

name
\angularimpulse

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

`\angularmomentum{⟨magnitude⟩}`
`\angularmomentumvector{⟨c_1, ..., c_n⟩}`
`\vectorangularmomentum{⟨c_1, ..., c_n⟩}`

name
\angularmomentum

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

`\angularvelocity{⟨magnitude⟩}`
`\angularvelocityvector{⟨c_1, ..., c_n⟩}`
`\vectorangularvelocity{⟨c_1, ..., c_n⟩}`

name
\angularvelocity

base	**derived**	**alternate**
$\mathrm{rad \cdot s^{-1}}$	$\mathrm{rad/s}$	$\mathrm{rad/s}$

`\area{⟨magnitude⟩}`

name
\area

base	**derived**	**alternate**
$\mathrm{m^2}$	$\mathrm{m^2}$	$\mathrm{m^2}$

`\areachargedensity{⟨magnitude⟩}`

name
\areachargedensity

base	**derived**	**alternate**
$\mathrm{A \cdot s \cdot m^{-2}}$	$\mathrm{C/m^2}$	$\mathrm{C/m^2}$

`\areamassdensity{⟨magnitude⟩}`

name
\areamassdensity

base	**derived**	**alternate**
$\mathrm{kg \cdot m^{-2}}$	$\mathrm{kg/m^2}$	$\mathrm{kg/m^2}$

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\capacitance{⟨*magnitude*⟩}

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

\charge{⟨*magnitude*⟩}

name
\charge
base	**derived**	**alternate**
$A \cdot s$	C	C

\cmagneticfield{⟨*magnitude*⟩}
\cmagneticfieldvector{⟨$c_1, \ldots, c_n$⟩}
\vectorcmagneticfield{⟨$c_1, \ldots, c_n$⟩}

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

\conductance{⟨*magnitude*⟩}

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

\conductivity{⟨*magnitude*⟩}

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

\conventionalcurrent{⟨*magnitude*⟩}

name
\conventionalcurrent
base	**derived**	**alternate**
A	C/s	A

\current{⟨*magnitude*⟩}

name

\current

base	derived	alternate
A	A	A

\currentdensity{⟨*magnitude*⟩}
\currentdensityvector{⟨$c_1, ..., c_n$⟩}
\vectorcurrentdensity{⟨$c_1, ..., c_n$⟩}

name

\currentdensity

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

\dielectricconstant{⟨*magnitude*⟩}

name

\dielectricconstant

base	derived	alternate

\direction{⟨*magnitude*⟩}
\directionvector{⟨$c_1, ..., c_n$⟩}
\vectordirection{⟨$c_1, ..., c_n$⟩}

name

\direction

base	derived	alternate

\displacement{⟨*magnitude*⟩}
\displacementvector{⟨$c_1, ..., c_n$⟩}
\vectordisplacement{⟨$c_1, ..., c_n$⟩}

name

\displacement

base	derived	alternate
m	m	m

\duration{⟨*magnitude*⟩}

name

\duration

base	derived	alternate
s	s	s

\electricdipolemoment{⟨*magnitude*⟩}
\electricdipolemomentvector{⟨$c_1, \ldots, c_n$⟩}
\vectorelectricdipolemoment{⟨$c_1, \ldots, c_n$⟩}

name

\electricdipolemoment

base	derived	alternate
$\mathrm{A \cdot s \cdot m}$	$\mathrm{C \cdot m}$	$\mathrm{C \cdot m}$

\electricfield{⟨*magnitude*⟩}
\electricfieldvector{⟨$c_1, \ldots, c_n$⟩}
\vectorelectricfield{⟨$c_1, \ldots, c_n$⟩}

name

\electricfield

base	derived	alternate
$\mathrm{kg \cdot m \cdot A^{-1} \cdot s^{-3}}$	$\mathrm{V/m}$	$\mathrm{N/C}$

\electricflux{⟨*magnitude*⟩}

name

\electricflux

base	derived	alternate
$\mathrm{kg \cdot m^3 \cdot A^{-1} \cdot s^{-3}}$	$\mathrm{V \cdot m}$	$\mathrm{N \cdot m^2/C}$

\electricpotential{⟨*magnitude*⟩}

name

\electricpotential

base	derived	alternate
$\mathrm{kg \cdot m^2 \cdot A^{-1} \cdot s^{-3}}$	V	V

\electricpotentialdifference{⟨*magnitude*⟩}

name

\electricpotentialdifference

base	derived	alternate
$\mathrm{kg \cdot m^2 \cdot A^{-1} \cdot s^{-3}}$	V	V

\electroncurrent{⟨*magnitude*⟩}

name

\electroncurrent

base	derived	alternate
$\mathrm{s^{-1}}$	$\mathrm{e/s}$	$\mathrm{e/s}$

\emf{⟨*magnitude*⟩}

name
\emf

base	**derived**	**alternate**
$\mathrm{kg} \cdot \mathrm{m}^2 \cdot \mathrm{A}^{-1} \cdot \mathrm{s}^{-3}$	V	V

\energy{⟨*magnitude*⟩}

name
\energy

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

N 2021-04-15   **\energyinev**{⟨*magnitude*⟩}

name
\energyinev

base	**derived**	**alternate**
eV	eV	eV

N 2021-04-15   **\energyinkev**{⟨*magnitude*⟩}

name
\energyinkev

base	**derived**	**alternate**
keV	keV	keV

N 2021-04-15   **\energyinmev**{⟨*magnitude*⟩}

name
\energyinmev

base	**derived**	**alternate**
MeV	MeV	MeV

\energydensity{⟨*magnitude*⟩}

name
\energydensity

base	**derived**	**alternate**
$\mathrm{kg} \cdot \mathrm{m}^{-1} \cdot \mathrm{s}^{-2}$	$\mathrm{J/m}^3$	$\mathrm{J/m}^3$

\energyflux{⟨*magnitude*⟩}

N 2021-02-24   **\energyfluxvector**{⟨$c_1, \ldots, c_n$⟩}

\vectorenergyflux{⟨$c_1, \ldots, c_n$⟩}

name
\energyflux

base	**derived**	**alternate**
$\mathrm{kg}\cdot\mathrm{s}^{-3}$	$\mathrm{W/m^2}$	$\mathrm{W/m^2}$

\entropy{⟨*magnitude*⟩}

name
\entropy

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

\force{⟨*magnitude*⟩}
\forcevector{⟨$c_1,\dots,c_n$⟩}
\vectorforce{⟨$c_1,\dots,c_n$⟩}

name
\force

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

\frequency{⟨*magnitude*⟩}

name
\frequency

base	**derived**	**alternate**
s^{-1}	Hz	Hz

\gravitationalfield{⟨*magnitude*⟩}
\gravitationalfieldvector{⟨$c_1,\dots,c_n$⟩}
\vectorgravitationalfield{⟨$c_1,\dots,c_n$⟩}

name
\gravitationalfield

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

\gravitationalpotential{⟨*magnitude*⟩}

name
\gravitationalpotential

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

\gravitationalpotentialdifference{⟨*magnitude*⟩}

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name

`\gravitationalpotentialdifference`

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

\impulse{⟨*magnitude*⟩}
\impulsevector{⟨$c_1, \ldots, c_n$⟩}
\vectorimpulse{⟨$c_1, \ldots, c_n$⟩}

name

`\impulse`

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

\indexofrefraction{⟨*magnitude*⟩}

name

`\indexofrefraction`

base	derived	alternate

\inductance{⟨*magnitude*⟩}

name

`\inductance`

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

\linearchargedensity{⟨*magnitude*⟩}

name

`\linearchargedensity`

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

\linearmassdensity{⟨*magnitude*⟩}

name

`\linearmassdensity`

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

\luminousintensity{⟨*magnitude*⟩}

name

`\luminousintensity`

base	derived	alternate
cd	cd	cd

\magneticcharge{⟨*magnitude*⟩}

name
\magneticcharge

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

\magneticdipolemoment{⟨*magnitude*⟩}
\magneticdipolemomentvector{⟨$c_1, \dots, c_n$⟩}
\vectormagneticdipolemoment{⟨$c_1, \dots, c_n$⟩}

name
\magneticdipolemoment

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

\magneticfield{⟨*magnitude*⟩}
\magneticfieldvector{⟨$c_1, \dots, c_n$⟩}
\vectormagneticfield{⟨$c_1, \dots, c_n$⟩}

name
\magneticfield

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

\magneticflux{⟨*magnitude*⟩}

name
\magneticflux

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

\mass{⟨*magnitude*⟩}

name
\mass

base	derived	alternate
kg	kg	kg

\mobility{⟨*magnitude*⟩}

name
\mobility

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

\momentofinertia{⟨*magnitude*⟩}

name
\momentofinertia

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

\momentum{⟨*magnitude*⟩}
\momentumvector{⟨$c_1, \dots, c_n$⟩}
\vectormomentum{⟨$c_1, \dots, c_n$⟩}

name
\momentum

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

\momentumflux{⟨*magnitude*⟩}
\momentumfluxvector{⟨$c_1, \dots, c_n$⟩}
\vectormomentumflux{⟨$c_1, \dots, c_n$⟩}

name
\momentumflux

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

\numberdensity{⟨*magnitude*⟩}

name
\numberdensity

base	derived	alternate
m^{-3}	$/\mathrm{m}^3$	$/\mathrm{m}^3$

\permeability{⟨*magnitude*⟩}

name
\permeability

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

\permittivity{⟨*magnitude*⟩}

name
\permittivity

base	derived	alternate
$\mathrm{A}^2 \cdot \mathrm{s}^4 \cdot \mathrm{kg}^{-1} \cdot \mathrm{m}^{-3}$	$\mathrm{F/m}$	$\mathrm{C}^2/\mathrm{N} \cdot \mathrm{m}^2$

\planeangle{⟨*magnitude*⟩}

name
\planeangle

base	derived	alternate
$\mathrm{m} \cdot \mathrm{m}^{-1}$	rad	rad

\polarizability{⟨*magnitude*⟩}

name
\polarizability

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

\power{⟨*magnitude*⟩}

name
\power

base	derived	alternate
$\mathrm{kg} \cdot \mathrm{m}^2 \cdot \mathrm{s}^{-3}$	W	J/s

\poynting{⟨*magnitude*⟩}
\poyntingvector{⟨$c_1, \ldots, c_n$⟩}
\vectorpoynting{⟨$c_1, \ldots, c_n$⟩}

name
\poynting

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

\pressure{⟨*magnitude*⟩}

name
\pressure

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

\relativepermeability{⟨*magnitude*⟩}

name
\relativepermeability

base	derived	alternate

\relativepermittivity{⟨*magnitude*⟩}

name
\relativepermittivity
    base   **derived**   **alternate**

\resistance{⟨*magnitude*⟩}

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

\resistivity{⟨*magnitude*⟩}

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

\solidangle{⟨*magnitude*⟩}

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

\specificheatcapacity{⟨*magnitude*⟩}

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

\springstiffness{⟨*magnitude*⟩}

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

\springstretch{⟨*magnitude*⟩}

name
\springstretch
base	derived	alternate
m	m	m

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\stress{⟨*magnitude*⟩}

name
\stress

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

\strain{⟨*magnitude*⟩}

name
\strain

base	**derived**	**alternate**

\temperature{⟨*magnitude*⟩}

name
\temperature

base	**derived**	**alternate**
K	K	K

\torque{⟨*magnitude*⟩}
\torquevector{⟨$c_1, \dots, c_n$⟩}
\vectortorque{⟨$c_1, \dots, c_n$⟩}

name
\torque

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

\velocity{⟨*magnitude*⟩}
\velocityvector{⟨$c_1, \dots, c_n$⟩}
\vectorvelocity{⟨$c_1, \dots, c_n$⟩}
\velocityc{⟨*magnitude*⟩}
\velocitycvector{⟨$c_1, \dots, c_n$⟩}
\vectorvelocityc{⟨$c_1, \dots, c_n$⟩}

name
\velocity

base	**derived**	**alternate**
$\mathrm{m} \cdot \mathrm{s}^{-1}$	m/s	m/s

name
\velocityc

base	**derived**	**alternate**
c	c	c

\volume{⟨*magnitude*⟩}

name
\volume

base	**derived**	**alternate**
m^3	m^3	m^3

\volumechargedensity{⟨*magnitude*⟩}

name
\volumechargedensity

base	**derived**	**alternate**
$\mathrm{A \cdot s/m^{-3}}$	$\mathrm{C/m^3}$	$\mathrm{C/m^3}$

\volumemassdensity{⟨*magnitude*⟩}

name
\volumemassdensity

base	**derived**	**alternate**
$\mathrm{kg \cdot m^{-3}}$	$\mathrm{kg/m^3}$	$\mathrm{kg/m^3}$

\wavelength{⟨*magnitude*⟩}

name
\wavelength

base	**derived**	**alternate**
m	m	m

\wavenumber{⟨*magnitude*⟩}
\wavenumbervector{⟨$c_1, ..., c_n$⟩}
\vectorwavenumber{⟨$c_1, ..., c_n$⟩}

name
\wavenumber

base	**derived**	**alternate**
m^{-1}	/m	/m

\work{⟨*magnitude*⟩}

name
\work

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

\youngsmodulus{⟨*magnitude*⟩}

name
\youngsmodulus

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

3.4.4 Defining and Redefining Physical Quantities

\newscalarquantity{⟨*name*⟩}{⟨*base units*⟩}[⟨*derived units*⟩][⟨*alternate units*⟩]
\renewscalarquantity{⟨*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.

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

3.4.5 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$^{→ \text{P. }9}$ or physical constant$^{→ \text{P. }25}$ is defined, a global modal command (switch), a command that sets units for a single instance, and an environment that sets units for its duration. All of these methods work for both physical quantities and physical constants.

\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.

\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.

```
\( \hereusebaseunits{\momentum{5}} \)       \\      5 kg · m · s⁻¹
\( \hereusederivedunits{\momentum{5}} \)     \\      5 kg · m/s
\( \hereusealternateunits{\momentum{5}} \)  \\      5 kg · m/s
\( \hereusebaseunits{\oofpez} \)             \\      9 × 10⁹ kg · m³ · A⁻² · s⁻⁴
\( \hereusederivedunits{\oofpez} \)          \\      9 × 10⁹ m/F
\( \hereusealternateunits{\oofpez} \)               9 × 10⁹ N · m²/C²
```

$$5\,\mathrm{kg\cdot m\cdot s^{-1}}$$
$$5\,\mathrm{kg\cdot m/s}$$
$$5\,\mathrm{kg\cdot m/s}$$
$$9\times 10^{9}\,\mathrm{kg\cdot m^{3}\cdot A^{-2}\cdot s^{-4}}$$
$$9\times 10^{9}\,\mathrm{m/F}$$
$$9\times 10^{9}\,\mathrm{N\cdot m^{2}/C^{2}}$$

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

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

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

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

```
\( \momentum{5} \)    \\
\( \oofpez \)         \\
\begin{usebaseunits}
  \( \momentum{5} \) \\
  \( \oofpez \)       \\
\end{usebaseunits}
\begin{usederivedunits}
  \( \momentum{5} \) \\
  \( \oofpez \)       \\
\end{usederivedunits}
\begin{usealternateunits}
  \( \momentum{5} \) \\
  \( \oofpez \)
\end{usealternateunits}
```

$5\,\mathrm{kg} \cdot \mathrm{m/s}$

$9 \times 10^9\,\mathrm{N} \cdot \mathrm{m}^2/\mathrm{C}^2$

$5\,\mathrm{kg} \cdot \mathrm{m} \cdot \mathrm{s}^{-1}$

$9 \times 10^9\,\mathrm{kg} \cdot \mathrm{m}^3 \cdot \mathrm{A}^{-2} \cdot \mathrm{s}^{-4}$

$5\,\mathrm{kg} \cdot \mathrm{m/s}$

$9 \times 10^9\,\mathrm{m/F}$

$5\,\mathrm{kg} \cdot \mathrm{m/s}$

$9 \times 10^9\,\mathrm{N} \cdot \mathrm{m}^2/\mathrm{C}^2$

3.5 Physical Constants

3.5.1 Typesetting Physical Constants

Take the quantity $\frac{1}{4\pi\epsilon_\mathrm{o}}$, 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.

```
\( \oofpez \)                     \\
\( \oofpezapproximatevalue \)     \\
\( \oofpezprecisevalue \)         \\
\( \oofpezmathsymbol \)           \\
\( \oofpezbaseunits \)            \\
\( \oofpezderivedunits \)         \\
\( \oofpezalternateunits \)       \\
\( \oofpezonlybaseunits \)        \\
\( \oofpezonlyderivedunits \)     \\
\( \oofpezonlyalternateunits \)
```

$9 \times 10^9\,\mathrm{N} \cdot \mathrm{m}^2/\mathrm{C}^2$

9×10^9

8.9875517923×10^9

$\frac{1}{4\pi\epsilon_\mathrm{o}}$

$9 \times 10^9\,\mathrm{kg} \cdot \mathrm{m}^3 \cdot \mathrm{A}^{-2} \cdot \mathrm{s}^{-4}$

$9 \times 10^9\,\mathrm{m/F}$

$9 \times 10^9\,\mathrm{N} \cdot \mathrm{m}^2/\mathrm{C}^2$

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

$\mathrm{m/F}$

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

3.5.2 Checking Physical Constants

\checkconstant{⟨*name*⟩}

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

3.5.3 Predefined Physical Constants

Every other defined physical constant can be treated similarly. Just replace oofpez with the constant's name. Unfortunately, there is no universal agreement on the names of every constant so don't fret if the names used here vary from other sources. Here are all the physical constants, with all their units, defined in mandi. The constants \coulombconstant[→ P. 27] and \biotsavartconstant are defined as semantic aliases for, respectively, \oofpez[→ P. 30] and \mzofp[→ P. 29].

\avogadro (exact)

name
\avogadro

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

\biotsavartconstant

name
\biotsavartconstant

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

\bohrradius

name
\bohrradius

symbol	**approximate**	**precise**
a_o	5.3×10^{-11}	$5.29177210903 \times 10^{-11}$
base	**derived**	**alternate**
m	m	m

\boltzmann (exact)

name
\boltzmann

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

\coulombconstant

name

\coulombconstant

symbol	**approximate**	**precise**
$\frac{1}{4\pi\epsilon_o}$	9×10^9	8.9875517923×10^9
base	**derived**	**alternate**
$\mathrm{kg \cdot m^3 \cdot A^{-2} \cdot s^{-4}}$	m/F	$\mathrm{N \cdot m^2/C^2}$

\earthmass

name

\earthmass

symbol	**approximate**	**precise**
$\mathrm{M_{Earth}}$	6.0×10^{24}	5.9722×10^{24}
base	**derived**	**alternate**
kg	kg	kg

\earthmoondistance

name

\earthmoondistance

symbol	**approximate**	**precise**
$\mathrm{d_{EM}}$	3.8×10^8	3.81550×10^8
base	**derived**	**alternate**
m	m	m

\earthradius

name

\earthradius

symbol	**approximate**	**precise**
$\mathrm{R_{Earth}}$	6.4×10^6	6.3781×10^6
base	**derived**	**alternate**
m	m	m

\earthsundistance

name

\earthsundistance

symbol	**approximate**	**precise**
$\mathrm{d_{ES}}$	1.5×10^{11}	1.496×10^{11}
base	**derived**	**alternate**
m	m	m

\electroncharge

name

\electroncharge

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

\electronCharge

name

\electronCharge

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

\electronmass

name

\electronmass

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

\elementarycharge (exact)

name

\elementarycharge

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

\finestructure

name

\finestructure

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

\hydrogenmass

name

`\hydrogenmass`

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

\moonearthdistance

name

`\moonearthdistance`

symbol	**approximate**	**precise**
d_{ME}	3.8×10^8	3.81550×10^8
base	**derived**	**alternate**
m	m	m

\moonmass

name

`\moonmass`

symbol	**approximate**	**precise**
M_{Moon}	7.3×10^{22}	7.342×10^{22}
base	**derived**	**alternate**
kg	kg	kg

\moonradius

name

`\moonradius`

symbol	**approximate**	**precise**
R_{Moon}	1.7×10^6	1.7371×10^6
base	**derived**	**alternate**
m	m	m

\mzofp

name

`\mzofp`

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

\neutronmass

name

`\neutronmass`

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

name

`\oofpez`

symbol	**approximate**	**precise**
$\frac{1}{4\pi\epsilon_o}$	9×10^9	8.9875517923×10^9
base	**derived**	**alternate**
$\mathrm{kg} \cdot \mathrm{m}^3 \cdot \mathrm{A}^{-2} \cdot \mathrm{s}^{-4}$	m/F	$\mathrm{N} \cdot \mathrm{m}^2 / \mathrm{C}^2$

name

`\oofpezcs`

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

(exact)

name

`\planck`

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

name

`\planckbar`

symbol	**approximate**	**precise**
ℏ	1.1×10^{-34}	$1.054571817 \times 10^{-34}$
base	**derived**	**alternate**
$\mathrm{kg} \cdot \mathrm{m}^2 \cdot \mathrm{s}^{-1}$	$\mathrm{J} \cdot \mathrm{s}$	$\mathrm{J} \cdot \mathrm{s}$

name

`\planckc`

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

`\protoncharge`

name

`\protoncharge`

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

`\protonCharge`

name

`\protonCharge`

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

`\protonmass`

name

`\protonmass`

symbol	**approximate**	**precise**
m_p	1.7×10^{-27}	$1.672621898 \times 10^{-27}$
base	**derived**	**alternate**
kg	kg	kg

`\rydberg`

name

`\rydberg`

symbol	**approximate**	**precise**
R_∞	1.1×10^7	$1.0973731568160 \times 10^7$
base	**derived**	**alternate**
m^{-1}	m^{-1}	m^{-1}

`\speedoflight` (exact)

name
`\speedoflight`

symbol	approximate	precise
c	3×10^8	2.99792458×10^8
base	**derived**	**alternate**
$\mathrm{m \cdot s^{-1}}$	m/s	m/s

\stefanboltzmann

name
`\stefanboltzmann`

symbol	approximate	precise
σ	5.7×10^{-8}	5.670374×10^{-8}
base	**derived**	**alternate**
$\mathrm{kg \cdot s^{-3} \cdot K^{-4}}$	$\mathrm{W/m^2 \cdot K^4}$	$\mathrm{W/m^2 \cdot K^4}$

\sunearthdistance

name
`\sunearthdistance`

symbol	approximate	precise
$\mathrm{d_{SE}}$	1.5×10^{11}	1.496×10^{11}
base	**derived**	**alternate**
m	m	m

\sunradius

name
`\sunradius`

symbol	approximate	precise
$\mathrm{R_{Sun}}$	7.0×10^8	6.957×10^8
base	**derived**	**alternate**
m	m	m

\surfacegravfield

name
`\surfacegravfield`

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

\universalgrav

name

\universalgrav

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

\vacuumpermeability

name

\vacuumpermeability

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

\vacuumpermittivity

name

\vacuumpermittivity

symbol	approximate	precise
ϵ_o	9×10^{-12}	$8.854187817 \times 10^{-12}$
base	**derived**	**alternate**
$\mathrm{A}^2 \cdot \mathrm{s}^4 \cdot \mathrm{kg}^{-1} \cdot \mathrm{m}^{-3}$	$\mathrm{F/m}$	$\mathrm{C}^2/\mathrm{N} \cdot \mathrm{m}^2$

3.5.4 Defining and Redefining Physical Constants

N 2021-02-16 \newphysicalconstant {⟨*name*⟩}{⟨*symbol*⟩}{⟨*approximate value*⟩}{⟨*precise value*⟩}{⟨*base units*⟩} [⟨*derived units*⟩] [⟨*alternate units*⟩]

N 2021-02-21 \renewphysicalconstant {⟨*name*⟩}{⟨*symbol*⟩}{⟨*approximate value*⟩}{⟨*precise value*⟩}{⟨*base units*⟩} [⟨*derived units*⟩] [⟨*alternate units*⟩]

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

3.5.5 Changing Precision

Changing units[→ P. 24] works for physical constants just as it does for physical quantities. A similar mechanism is provided for changing the precision of physical constants' numerical values.

N 2021-02-16 \alwaysuseapproximateconstants

N 2021-02-16 \alwaysusepreciseconstants

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

N 2021-02-16 \hereuseapproximateconstants{⟨*content*⟩}

N 2021-02-16 \hereusepreciseconstants{⟨*content*⟩}

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

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

$8.9875517923 \times 10^9 \, \text{N} \cdot \text{m}^2/\text{C}^2$

```
\begin{useapproximateconstants}
  ⟨environment content⟩
\end{useapproximateconstants}
```
(use approximate constants)

```
\begin{usepreciseconstants}
  ⟨environment content⟩
\end{usepreciseconstants}
```
(use precise constants)

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

```
\( \oofpez \)                    \\
\begin{useapproximateconstants}
  \( \oofpez \)                  \\
\end{useapproximateconstants}
\begin{usepreciseconstants}
  \( \oofpez \)                  \\
\end{usepreciseconstants}
\( \oofpez \)
```

$9 \times 10^9 \, \text{N} \cdot \text{m}^2/\text{C}^2$
$9 \times 10^9 \, \text{N} \cdot \text{m}^2/\text{C}^2$
$8.9875517923 \times 10^9 \, \text{N} \cdot \text{m}^2/\text{C}^2$
$9 \times 10^9 \, \text{N} \cdot \text{m}^2/\text{C}^2$

3.6   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
\coulomb
\degree
\electronvolt
\ev
\farad
\henry
\hertz
\joule
\kelvin
\kev
\kiloelectronvolt
\kilogram
\lightspeed
```

(not SI but common in introductory physics)

(alias)

(alias)

(not SI but common in introductory physics)

(not SI but common relativity)

N 2021-04-15	`\megaelectronvolt`	(not SI but common in introductory physics)
	`\meter`	
	`\metre`	(alias)
N 2021-04-15	`\mev`	(alias)
	`\mole`	
	`\newton`	
	`\ohm`	
	`\pascal`	
	`\radian`	
	`\second`	
	`\siemens`	
	`\steradian`	
	`\tesla`	
	`\volt`	
	`\watt`	
	`\weber`	
	`\tothetwo`	(postfix)
	`\tothethree`	(postfix)
	`\tothefour`	(postfix)
	`\inverse`	(postfix)
	`\totheinversetwo`	(postfix)
	`\totheinversethree`	(postfix)
	`\totheinversefour`	(postfix)

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

\tento{⟨*number*⟩}
\timestento{⟨*number*⟩}
\xtento{⟨*number*⟩}

Commands for powers of ten and scientific notation.

36

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

\mivector[⟨*delimiter*⟩]{⟨$c_1, \dots, c_n$⟩}[⟨*units*⟩]

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

`\( \mivector{p_0,p_1,p_2,p_3} \)                          \\`
`\( \mivector{\gamma m v_x,\gamma m v_y,\gamma m v_z} \) \\`
`\( \mivector{\frac{Q_1Q_2}{x^2},0,0} \)                   \\`
`\( \mivector{-1,0,0} \)                                    \\`
`\( \mivector{-1,0,0}[\velocityonlyderivedunits] \)        \\`
`\( \mivector{-1,0,0}[\meter\per\second] \)                \\`
`\( \velocity{\mivector{-1,0,0}} \)`
	$\langle p_0, p_1, p_2, p_3 \rangle$
	$\langle \gamma m v_x, \gamma m v_y, \gamma m v_z \rangle$
	$\left\langle \frac{Q_1 Q_2}{x^2}, 0, 0 \right\rangle$
	$\langle -1, 0, 0 \rangle$
	$\langle -1, 0, 0 \rangle \ \mathrm{m/s}$
	$\langle -1, 0, 0 \rangle \ \mathrm{m/s}$
	$\langle -1, 0, 0 \rangle \, \mathrm{m/s}$

3.7 mandi Source Code

Definine the package version and date for global use, exploiting the fact that in a .sty file there is now no need for \makeatletter and \makeatother. This simplifies defining internal commands (with @ in the name) that are not for the user to know about.

```
1 \def\mandi@version{3.0.0}
2 \def\mandi@date{2021-08-21}
3 \NeedsTeXFormat{LaTeX2e}[2020-02-02]
4 \DeclareRelease{v3.0.0}{2021-08-21}{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{pgfopts}      % 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 \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 LaTeX kernel. Other parts have been rewriten in expl with a look to the future.

Generic internal selectors.

```
14 \newcommand*{\mandi@selectunits}{}
15 \newcommand*{\mandi@selectprecision}{}
```

Specific internal selectors.

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

Document level global switches.

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

Document level localized variants.

```
31 \NewDocumentCommand{\hereusebaseunits}{ m }{\begingroup\alwaysusebaseunits#1\endgroup}%
32 \NewDocumentCommand{\hereusederivedunits}{ m }{\begingroup\alwaysusederivedunits#1\endgroup}%
33 \NewDocumentCommand{\hereusealternateunits}{ m }{\begingroup\alwaysusealternateunits#1\endgroup}%
34 \NewDocumentCommand{\hereuseapproximateconstants}{ m }{\begingroup\alwaysuseapproximateconstants#1\endgroup}%
35 \NewDocumentCommand{\hereusepreciseconstants}{ m }{\begingroup\alwaysusepreciseconstants#1\endgroup}%
```

Document level environments.

```
36 \NewDocumentEnvironment{usebaseunits}{}{\alwaysusebaseunits}{}%
37 \NewDocumentEnvironment{usederivedunits}{}{\alwaysusederivedunits}{}%
38 \NewDocumentEnvironment{usealternateunits}{}{\alwaysusealternateunits}{}%
```

```
39 \NewDocumentEnvironment{useapproximateconstants}{}{\alwaysuseapproximateconstants}{}%
40 \NewDocumentEnvironment{usepreciseconstants}{}{\alwaysusepreciseconstants}{}%
```

mandi now has a key-value interface, implemented with pgfopts and pgfkeys. There are two options:

units[→P.8], with values **base**, **derived**, or **alternate** selects the default form of units

preciseconstants[→P.8], with values **true** and **false**, selects precise numerical values for constants rather than approximate values.

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

```
41 \newif\ifusingpreciseconstants
42 \pgfkeys{%
43   /mandi/options/.cd,
44   initial@setup/.style={%
45     /mandi/options/buffered@units/.initial=alternate,%
46   },%
47   initial@setup,%
48   preciseconstants/.is if=usingpreciseconstants,%
49   units/.is choice,%
50   units/.default=derived,%
51   units/alternate/.style={/mandi/options/buffered@units=alternate},%
52   units/base/.style={/mandi/options/buffered@units=base},%
53   units/derived/.style={/mandi/options/buffered@units=derived},%
54 }%
```

Process the options.

```
55 \ProcessPgfPackageOptions{/mandi/options}
```

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

```
56 \typeout{}%
57 \typeout{mandi: You are using mandi \mandiversion.}%
58 \typeout{mandi: This package requires LuaLaTeX.}%
59 \typeout{mandi: Loadtime options...}
```

Complete the banner by showing currently selected options. The value of the units[→P.8] key is used in situ to set the default units.

```
60 \newcommand*{\mandi@do@setup}{%
61   \csname alwaysuse\pgfkeysvalueof{/mandi/options/buffered@units}units\endcsname%
62   \typeout{mandi: You will get \pgfkeysvalueof{/mandi/options/buffered@units}\space units.}%
63   \ifusingpreciseconstants
64     \alwaysusepreciseconstants
65     \typeout{mandi: You will get precise constants.}%
66   \else
67     \alwaysuseapproximateconstants
68     \typeout{mandi: You will get approximate constants.}%
69   \fi
70   \typeout{}%
71 }%
72 \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.

```
73 \NewDocumentCommand{\mandisetup}{ m }{%
74   \IfValueT{#1}{%
75     \pgfqkeys{/mandi/options}{#1}
76     \typeout{}%
77     \typeout{mandi: mandisetup options...}
78     \mandi@do@setup
79   }%
80 }%
```

Define units and related constructs to be used with the unit engine. All single letter macros are now gone. We basically absorbed and adapted the now outdated Slunits package. We make use of \symup{...} from the unicode-math package.

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

127 \ExplSyntaxOn
128 \cs_new:Npn \mandi_newscalarquantity #1#2#3#4
129 {%
130   \cs_new:cpn {#1} ##1 {\unit{##1}{\mandi@selectunits{#2}{#3}{#4}}}%
131   \cs_new:cpn {#1value} ##1 {##1}%
132   \cs_new:cpn {#1baseunits} ##1 {\unit{##1}{\mandi@selectbaseunits{#2}{#3}{#4}}}%
133   \cs_new:cpn {#1derivedunits} ##1 {\unit{##1}{\mandi@selectderivedunits{#2}{#3}{#4}}}%
134   \cs_new:cpn {#1alternateunits} ##1 {\unit{##1}{\mandi@selectalternateunits{#2}{#3}{#4}}}%
135   \cs_new:cpn {#1onlybaseunits} {\mandi@selectbaseunits{#2}{#3}{#4}}%
136   \cs_new:cpn {#1onlyderivedunits} {\mandi@selectderivedunits{#2}{#3}{#4}}%
```

```
137    \cs_new:cpn {#1onlyalternateunits} {\mandi@selectalternateunits{#2}{#3}{#4}}%
138 }%
139 \NewDocumentCommand{\newscalarquantity}{ m m O{#2} O{#2} }%
140 {%
141    \mandi_newscalarquantity { #1 }{ #2 }{ #3 }{ #4 }%
142 }%
143 \ExplSyntaxOff
```

Redefining an existing scalar quantity.

```
144 \ExplSyntaxOn
145 \cs_new:Npn \mandi_renewscalarquantity #1#2#3#4
146 {%
147    \cs_set:cpn {#1} ##1 {\unit{##1}{\mandi@selectunits{#2}{#3}{#4}}}%
148    \cs_set:cpn {#1value} ##1 {##1}%
149    \cs_set:cpn {#1baseunits} ##1 {\unit{##1}{\mandi@selectbaseunits{#2}{#3}{#4}}}%
150    \cs_set:cpn {#1derivedunits} ##1 {\unit{##1}{\mandi@selectderivedunits{#2}{#3}{#4}}}%
151    \cs_set:cpn {#1alternateunits} ##1 {\unit{##1}{\mandi@selectalternateunits{#2}{#3}{#4}}}%
152    \cs_set:cpn {#1onlybaseunits} {\mandi@selectbaseunits{#2}{#3}{#4}}%
153    \cs_set:cpn {#1onlyderivedunits} {\mandi@selectderivedunits{#2}{#3}{#4}}%
154    \cs_set:cpn {#1onlyalternateunits} {\mandi@selectalternateunits{#2}{#3}{#4}}%
155 }%
156 \NewDocumentCommand{\renewscalarquantity}{ m m O{#2} O{#2} }%
157 {%
158    \mandi_renewscalarquantity { #1 }{ #2 }{ #3 }{ #4 }%
159 }%
160 \ExplSyntaxOff
```

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

```
161 \ExplSyntaxOn
162 \cs_new:Npn \mandi_newvectorquantity #1#2#3#4
163 {%
164    \mandi_newscalarquantity { #1 }{ #2 }{ #3 }{ #4 }%
165    \cs_new:cpn {vector#1} ##1 {\unit{\mivector{##1}}{\mandi@selectunits{#2}{#3}{#4}}}%
166    \cs_new:cpn {#1vector} ##1 {\unit{\mivector{##1}}{\mandi@selectunits{#2}{#3}{#4}}}%
167    \cs_new:cpn {vector#1value} ##1 {\mivector{##1}}%
168    \cs_new:cpn {#1vectorvalue} ##1 {\mivector{##1}}%
169    \cs_new:cpn {vector#1baseunits} ##1 {\unit{\mivector{##1}}{\mandi@selectbaseunits{#2}{#3}{#4}}}%
170    \cs_new:cpn {#1vectorbaseunits} ##1 {\unit{\mivector{##1}}{\mandi@selectbaseunits{#2}{#3}{#4}}}%
171    \cs_new:cpn {vector#1derivedunits} ##1 {\unit{\mivector{##1}}{\mandi@selectderivedunits{#2}{#3}{#4}}}%
172    \cs_new:cpn {#1vectorderivedunits} ##1 {\unit{\mivector{##1}}{\mandi@selectderivedunits{#2}{#3}{#4}}}%
173    \cs_new:cpn {vector#1alternateunits} ##1 {\unit{\mivector{##1}}{\mandi@selectalternateunits{#2}{#3}{#4}}}%
174    \cs_new:cpn {#1vectoralternateunits} ##1 {\unit{\mivector{##1}}{\mandi@selectalternateunits{#2}{#3}{#4}}}%
175    \cs_new:cpn {vector#1onlybaseunits} {\mandi@selectbaseunits{#2}{#3}{#4}}%
176    \cs_new:cpn {#1vectoronlybaseunits} {\mandi@selectbaseunits{#2}{#3}{#4}}%
177    \cs_new:cpn {vector#1onlyderivedunits} {\mandi@selectderivedunits{#2}{#3}{#4}}%
178    \cs_new:cpn {#1vectoronlyderivedunits} {\mandi@selectderivedunits{#2}{#3}{#4}}%
179    \cs_new:cpn {vector#1onlyalternateunits} {\mandi@selectalternateunits{#2}{#3}{#4}}%
180    \cs_new:cpn {#1vectoronlyalternateunits} {\mandi@selectalternateunits{#2}{#3}{#4}}%
181 }%
182 \NewDocumentCommand{\newvectorquantity}{ m m O{#2} O{#2} }%
183 {%
184    \mandi_newvectorquantity { #1 }{ #2 }{ #3 }{ #4 }%
185 }%
186 \ExplSyntaxOff
```

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

```
187 \ExplSyntaxOn
188 \cs_new:Npn \mandi_renewvectorquantity #1#2#3#4
189 {%
```

```
190   \mandi_renewscalarquantity { #1 }{ #2 }{ #3 }{ #4 }%
191   \cs_set:cpn {vector#1} ##1 {\unit{\mivector{##1}}{\mandi@selectunits{#2}{#3}{#4}}}%
192   \cs_set:cpn {#1vector} ##1 {\unit{\mivector{##1}}{\mandi@selectunits{#2}{#3}{#4}}}%
193   \cs_set:cpn {vector#1value} ##1 {\mivector{##1}}%
194   \cs_set:cpn {#1vectorvalue} ##1 {\mivector{##1}}%
195   \cs_set:cpn {vector#1baseunits} ##1 {\unit{\mivector{##1}}{\mandi@selectbaseunits{#2}{#3}{#4}}}%
196   \cs_set:cpn {#1vectorbaseunits} ##1 {\unit{\mivector{##1}}{\mandi@selectbaseunits{#2}{#3}{#4}}}%
197   \cs_set:cpn {vector#1derivedunits} ##1 {\unit{\mivector{##1}}{\mandi@selectderivedunits{#2}{#3}{#4}}}%
198   \cs_set:cpn {#1vectorderivedunits} ##1 {\unit{\mivector{##1}}{\mandi@selectderivedunits{#2}{#3}{#4}}}%
199   \cs_set:cpn {vector#1alternateunits} ##1 {\unit{\mivector{##1}}{\mandi@selectalternateunits{#2}{#3}{#4}}}%
200   \cs_set:cpn {#1vectoralternateunits} ##1 {\unit{\mivector{##1}}{\mandi@selectalternateunits{#2}{#3}{#4}}}%
201   \cs_set:cpn {vector#1onlybaseunits} {\mandi@selectbaseunits{#2}{#3}{#4}}%
202   \cs_set:cpn {#1vectoronlybaseunits} {\mandi@selectbaseunits{#2}{#3}{#4}}%
203   \cs_set:cpn {vector#1onlyderivedunits} {\mandi@selectderivedunits{#2}{#3}{#4}}%
204   \cs_set:cpn {#1vectoronlyderivedunits} {\mandi@selectderivedunits{#2}{#3}{#4}}%
205   \cs_set:cpn {vector#1onlyalternateunits} {\mandi@selectalternateunits{#2}{#3}{#4}}%
206   \cs_set:cpn {#1vectoronlyalternateunits} {\mandi@selectalternateunits{#2}{#3}{#4}}%
207 }%
208 \NewDocumentCommand{\renewvectorquantity}{ m m O{#2} O{#2} }%
209 {%
210   \mandi_renewvectorquantity { #1 }{ #2 }{ #3 }{ #4 }%
211 }%
212 \ExplSyntaxOff
```

Defining a new physical constant.

```
213 \ExplSyntaxOn
214 \cs_new:Npn \mandi_newphysicalconstant #1#2#3#4#5#6#7
215 {%
216   \cs_new:cpn {#1} {\unit{\mandi@selectprecision{#3}{#4}}{\mandi@selectunits{#5}{#6}{#7}}}%
217   \cs_new:cpn {#1mathsymbol} {#2}%
218   \cs_new:cpn {#1approximatevalue} {#3}%
219   \cs_new:cpn {#1precisevalue} {#4}%
220   \cs_new:cpn {#1baseunits}
221     {\unit{\mandi@selectprecision{#3}{#4}}{\mandi@selectbaseunits{#5}{#6}{#7}}}%
222   \cs_new:cpn {#1derivedunits}
223     {\unit{\mandi@selectprecision{#3}{#4}}{\mandi@selectderivedunits{#5}{#6}{#7}}}%
224   \cs_new:cpn {#1alternateunits}
225     {\unit{\mandi@selectprecision{#3}{#4}}{\mandi@selectalternateunits{#5}{#6}{#7}}}%
226   \cs_new:cpn {#1onlybaseunits} {\mandi@selectbaseunits{#5}{#6}{#7}}%
227   \cs_new:cpn {#1onlyderivedunits} {\mandi@selectderivedunits{#5}{#6}{#7}}%
228   \cs_new:cpn {#1onlyalternateunits} {\mandi@selectalternateunits{#5}{#6}{#7}}%
229 }%
230 \NewDocumentCommand{\newphysicalconstant}{ m m m m m O{#5} O{#5} }%
231 {%
232   \mandi_newphysicalconstant { #1 }{ #2 }{ #3 }{ #4 }{ #5 }{ #6 }{ #7 }%
233 }%
234 \ExplSyntaxOff
```

Redefining an existing physical constant.

```
235 \ExplSyntaxOn
236 \cs_new:Npn \mandi_renewphysicalconstant #1#2#3#4#5#6#7
237 {%
238   \cs_set:cpn {#1} {\unit{\mandi@selectprecision{#3}{#4}}{\mandi@selectunits{#5}{#6}{#7}}}%
239   \cs_set:cpn {#1mathsymbol} {#2}%
240   \cs_set:cpn {#1approximatevalue} {#3}%
241   \cs_set:cpn {#1precisevalue} {#4}%
242   \cs_set:cpn {#1baseunits}
243     {\unit{\mandi@selectprecision{#3}{#4}}{\mandi@selectbaseunits{#5}{#6}{#7}}}%
244   \cs_set:cpn {#1derivedunits}
```

```
245      {\unit{\mandi@selectprecision{#3}{#4}}{\mandi@selectderivedunits{#5}{#6}{#7}}}%
246    \cs_set:cpn {#1alternateunits}
247      {\unit{\mandi@selectprecision{#3}{#4}}{\mandi@selectalternateunits{#5}{#6}{#7}}}%
248    \cs_set:cpn {#1onlybaseunits} {\mandi@selectbaseunits{#5}{#6}{#7}}%
249    \cs_set:cpn {#1onlyderivedunits} {\mandi@selectderivedunits{#5}{#6}{#7}}%
250    \cs_set:cpn {#1onlyalternateunits} {\mandi@selectalternateunits{#5}{#6}{#7}}%
251 }%
252 \NewDocumentCommand{\renewphysicalconstant}{ m m m m m O{#5} O{#5} }
253 {%
254    \mandi_renewphysicalconstant { #1 }{ #2 }{ #3 }{ #4 }{ #5 }{ #6 }{ #7 }%
255 }%
256 \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.

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

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

```
359    {\kilogram\usk\meter\tothetwo\usk\ampere\inverse\usk\second\totheinversethree}%
360    [\volt]% % also \joule\per\coulomb
361    [\volt]%
362 \newscalarquantity{electroncurrent}%
363    {\second\inverse}%
364    [\ensuremath{\symup{e}}\per\second]%
365    [\ensuremath{\symup{e}}\per\second]%
366 \newscalarquantity{emf}%
367    {\kilogram\usk\meter\tothetwo\usk\ampere\inverse\usk\second\totheinversethree}%
368    [\volt]% % also \joule\per\coulomb
369    [\volt]%
370 \newscalarquantity{energy}%
371    {\kilogram\usk\meter\tothetwo\usk\second\totheinversetwo}%
372    [\joule]% % also \newton\usk\meter
373    [\joule]%
374 \newscalarquantity{energyinev}%
375    {\electronvolt}%
376 \newscalarquantity{energyinkev}%
377    {\kiloelectronvolt}%
378 \newscalarquantity{energyinmev}%
379    {\megaelectronvolt}%
380 \newscalarquantity{energydensity}%
381    {\kilogram\usk\meter\inverse\usk\second\totheinversetwo}%
382    [\joule\per\meter\tothethree]%
383    [\joule\per\meter\tothethree]%
384 \newscalarquantity{energyflux}%
385    {\kilogram\usk\second\totheinversethree}%
386    [\watt\per\meter\tothetwo]%
387    [\watt\per\meter\tothetwo]%
388 \newscalarquantity{entropy}%
389    {\kilogram\usk\meter\tothetwo\usk\second\totheinversetwo\usk\kelvin\inverse}%
390    [\joule\per\kelvin]%
391    [\joule\per\kelvin]%
392 \newvectorquantity{force}%
393    {\kilogram\usk\meter\usk\second\totheinversetwo}%
394    [\newton]%
395    [\newton]% % also \kilogram\usk\meter\per\second\tothetwo
396 \newscalarquantity{frequency}%
397    {\second\inverse}%
398    [\hertz]%
399    [\hertz]%
400 \newvectorquantity{gravitationalfield}%
401    {\meter\usk\second\totheinversetwo}%
402    [\newton\per\kilogram]%
403    [\newton\per\kilogram]%
404 \newscalarquantity{gravitationalpotential}%
405    {\meter\tothetwo\usk\second\totheinversetwo}%
406    [\joule\per\kilogram]%
407    [\joule\per\kilogram]%
408 \newscalarquantity{gravitationalpotentialdifference}%
409    {\meter\tothetwo\usk\second\totheinversetwo}%
410    [\joule\per\kilogram]%
411    [\joule\per\kilogram]%
412 \newvectorquantity{impulse}%
413    {\kilogram\usk\meter\usk\second\inverse}%
414    [\newton\usk\second]%
415    [\newton\usk\second]%
416 \newscalarquantity{indexofrefraction}%
417    {}%
```

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

```
477    {\meter\usk\meter\inverse}%
478    [\radian]%
479    [\radian]%
480 \newscalarquantity{polarizability}%
481    {\ampere\tothetwo\usk\second\tothefour\usk\kilogram\inverse}%
482    [\coulomb\usk\meter\tothetwo\per\volt]%
483    [\coulomb\tothetwo\usk\meter\per\newton]%
484 \newscalarquantity{power}%
485    {\kilogram\usk\meter\tothetwo\usk\second\totheinversethree}%
486    [\watt]%
487    [\joule\per\second]%
488 \newvectorquantity{poynting}%
489    {\kilogram\usk\second\totheinversethree}%
490    [\watt\per\meter\tothetwo]%
491    [\watt\per\meter\tothetwo]%
492 \newscalarquantity{pressure}%
493    {\kilogram\usk\meter\inverse\usk\second\totheinversetwo}%
494    [\pascal]%
495    [\newton\per\meter\tothetwo]%
496 \newscalarquantity{relativepermeability}
497    {}%
498 \newscalarquantity{relativepermittivity}%
499    {}%
500 \newscalarquantity{resistance}%
501    {\kilogram\usk\meter\tothetwo\usk\ampere\totheinversetwo\usk\second\totheinversethree}%
502    [\ohm]% % also \volt\per\ampere
503    [\ohm]%
504 \newscalarquantity{resistivity}%
505    {\kilogram\usk\meter\tothethree\usk\ampere\totheinversetwo\usk\second\totheinversethree}%
506    [\ohm\usk\meter]%
507    [\volt\usk\meter\per\ampere]%
508 \newscalarquantity{solidangle}%
509    {\meter\tothetwo\usk\meter\totheinversetwo}%
510    [\steradian]%
511    [\steradian]%
512 \newscalarquantity{specificheatcapacity}%
513    {\meter\tothetwo\usk\second\totheinversetwo\usk\kelvin\inverse}%
514    [\joule\per\kelvin\usk\kilogram]%
515    [\joule\per\kelvin\usk\kilogram]
516 \newscalarquantity{springstiffness}%
517    {\kilogram\usk\second\totheinversetwo}%
518    [\newton\per\meter]%
519    [\newton\per\meter]%
520 \newscalarquantity{springstretch}% % This is really just a displacement.
521    {\meter}%
522 \newscalarquantity{stress}%
523    {\kilogram\usk\meter\inverse\usk\second\totheinversetwo}%
524    [\pascal]%
525    [\newton\per\meter\tothetwo]%
526 \newscalarquantity{strain}%
527    {}%
528 \newscalarquantity{temperature}%
529    {\kelvin}%
530 %\ifmandi@rotradians
531 %   \newphysicalquantity{torque}%
532 %     {\kilogram\usk\meter\tothetwo\usk\second\totheinversetwo\usk\radian\inverse}%
533 %     [\newton\usk\meter\per\radian]%
534 %     [\newton\usk\meter\per\radian]%
535 %\else
```

```
536 \newvectorquantity{torque}%
537   {\kilogram\usk\meter\tothetwo\usk\second\totheinversetwo}%
538   [\newton\usk\meter]%
539   [\newton\usk\meter]%
540 %\fi
541 \newvectorquantity{velocity}%
542   {\meter\usk\second\inverse}%
543   [\meter\per\second]%
544   [\meter\per\second]%
545 \newvectorquantity{velocityc}%
546   {\lightspeed}%
547   [\lightspeed]%
548   [\lightspeed]%
549 \newscalarquantity{volume}%
550   {\meter\tothethree}%
551 \newscalarquantity{volumechargedensity}%
552   {\ampere\usk\second\per\meter\totheinversethree}%
553   [\coulomb\per\meter\tothethree]%
554   [\coulomb\per\meter\tothethree]%
555 \newscalarquantity{volumemassdensity}%
556   {\kilogram\usk\meter\totheinversethree}%
557   [\kilogram\per\meter\tothethree]%
558   [\kilogram\per\meter\tothethree]%
559 \newscalarquantity{wavelength}% % This is really just a displacement.
560   {\meter}%
561 \newvectorquantity{wavenumber}%
562   {\meter\inverse}%
563   [\per\meter]%
564   [\per\meter]%
565 \newscalarquantity{work}%
566   {\kilogram\usk\meter\tothetwo\usk\second\totheinversetwo}%
567   [\joule]% % also \newton\usk\meter but discouraged
568   [\joule]%
569 \newscalarquantity{youngsmodulus}% % This is really just a stress.
570   {\kilogram\usk\meter\inverse\usk\second\totheinversetwo}%
571   [\pascal]%
572   [\newton\per\meter\tothetwo]%
```

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

```
573 \newphysicalconstant{avogadro}%
574   {\symup{N_A}}%
575   {6\timestento{23}}{6.02214076\timestento{23}}% % exact 2019 value
576   {\mole\inverse}%
577   [\per\mole]%
578   [\per\mole]%
579 \newphysicalconstant{biotsavartconstant}% % alias for \mzofp
580   {\symup{\frac{\mu_o}{4\pi}}}%
581   {\tento{-7}}{\tento{-7}}%
582   {\kilogram\usk\meter\usk\ampere\totheinversetwo\usk\second\totheinversetwo}%
583   [\henry\per\meter]%
584   [\tesla\usk\meter\per\ampere]%
585 \newphysicalconstant{bohrradius}%
586   {\symup{a_o}}%
587   {5.3\timestento{-11}}{5.29177210903\timestento{-11}}%
588   {\meter}%
589 \newphysicalconstant{boltzmann}%
590   {\symup{k_B}}%
591   {1.4\timestento{-23}}{1.380649\timestento{-23}}% % exact 2019 value
592   {\kilogram\usk\meter\tothetwo\usk\second\totheinversetwo\usk\kelvin\inverse}%
```

```
593    [\joule\per\kelvin]%
594    [\joule\per\kelvin]%
595 \newphysicalconstant{coulombconstant}% % alias for \oofpez
596    {\symup{\frac{1}{4}\pi\epsilon_o}}}%
597    {9\timestento{9}}{8.9875517923\timestento{9}}%
598    {\kilogram\usk\meter\tothethree\usk\ampere\totheinversetwo\usk\second\totheinversefour}%
599    [\meter\per\farad]%
600    [\newton\usk\meter\tothetwo\per\coulomb\tothetwo]%
601 \newphysicalconstant{earthmass}%
602    {\symup{M_{Earth}}}%
603    {6.0\timestento{24}}{5.9722\timestento{24}}%
604    {\kilogram}%
605 \newphysicalconstant{earthmoondistance}%
606    {\symup{d_{EM}}}%
607    {3.8\timestento{8}}{3.81550\timestento{8}}%
608    {\meter}%
609 \newphysicalconstant{earthradius}%
610    {\symup{R_{Earth}}}%
611    {6.4\timestento{6}}{6.3781\timestento{6}}%
612    {\meter}%
613 \newphysicalconstant{earthsundistance}%
614    {\symup{d_{ES}}}%
615    {1.5\timestento{11}}{1.496\timestento{11}}%
616    {\meter}%
617 \newphysicalconstant{electroncharge}%
618    {\symup{q_e}}%
619    {-\elementarychargeapproximatevalue}{-\elementarychargeprecisevalue}%
620    {\ampere\usk\second}%
621    [\coulomb]%
622    [\coulomb]%
623 \newphysicalconstant{electronCharge}%
624    {\symup{Q_e}}%
625    {-\elementarychargeapproximatevalue}{-\elementarychargeprecisevalue}%
626    {\ampere\usk\second}%
627    [\coulomb]%
628    [\coulomb]%
629 \newphysicalconstant{electronmass}%
630    {\symup{m_e}}%
631    {9.1\timestento{-31}}{9.1093837015\timestento{-31}}%
632    {\kilogram}%
633 \newphysicalconstant{elementarycharge}%
634    {\symup{e}}%
635    {1.6\timestento{-19}}{1.602176634\timestento{-19}}% % exact 2019 value
636    {\ampere\usk\second}%
637    [\coulomb]%
638    [\coulomb]%
639 \newphysicalconstant{finestructure}%
640    {\symup{\alpha}}%
641    {\frac{1}{137}}{7.2973525693\timestento{-3}}%
642    {}%
643 \newphysicalconstant{hydrogenmass}%
644    {\symup{m_H}}%
645    {1.7\timestento{-27}}{1.6737236\timestento{-27}}%
646    {\kilogram}%
647 \newphysicalconstant{moonearthdistance}%
648    {\symup{d_{ME}}}%
649    {3.8\timestento{8}}{3.81550\timestento{8}}%
650    {\meter}%
651 \newphysicalconstant{moonmass}%
```

```
652    {\symup{M_{Moon}}}%
653    {7.3\timestento{22}}{7.342\timestento{22}}%
654    {\kilogram}%
655 \newphysicalconstant{moonradius}%
656    {\symup{R_{Moon}}}%
657    {1.7\timestento{6}}{1.7371\timestento{6}}%
658    {\meter}%
659 \newphysicalconstant{mzofp}%
660    {\symup{\frac{\mu_o}{4\pi}}}%
661    {\tento{-7}}{\tento{-7}}%
662    {\kilogram\usk\meter\usk\ampere\totheinversetwo\usk\second\totheinversetwo}%
663    [\henry\per\meter]%
664    [\tesla\usk\meter\per\ampere]%
665 \newphysicalconstant{neutronmass}%
666    {\symup{m_n}}%
667    {1.7\timestento{-27}}{1.67492749804\timestento{-27}}%
668    {\kilogram}%
669 \newphysicalconstant{oofpez}%
670    {\symup{\frac{1}{4\pi\epsilon_o}}}%
671    {9\timestento{9}}{8.9875517923\timestento{9}}%
672    {\kilogram\usk\meter\tothethree\usk\ampere\totheinversetwo\usk\second\totheinversefour}%
673    [\meter\per\farad]%
674    [\newton\usk\meter\tothetwo\per\coulomb\tothetwo]%
675 \newphysicalconstant{oofpezcs}%
676    {\symup{\frac{1}{4\pi\epsilon_o c^2}}}%
677    {\tento{-7}}{\tento{-7}}%
678    {\kilogram\usk\meter\usk\ampere\totheinversetwo\usk\second\totheinversetwo}%
679    [\tesla\usk\meter\tothetwo]%
680    [\newton\usk\second\tothetwo\per\coulomb\tothetwo]%
681 \newphysicalconstant{planck}%
682    {\symup{h}}%
683    {6.6\timestento{-34}}{6.62607015\timestento{-34}}% % exact 2019 value
684    {\kilogram\usk\meter\tothetwo\usk\second\inverse}%
685    [\joule\usk\second]%
686    [\joule\usk\second]%

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

687 \newphysicalconstant{planckbar}%
688    {\symup{\lower0.18ex\hbox{\mathchar"AF}\mkern-7mu h}}%
689    {1.1\timestento{-34}}{1.054571817\timestento{-34}}%
690    {\kilogram\usk\meter\tothetwo\usk\second\inverse}%
691    [\joule\usk\second]%
692    [\joule\usk\second]
693 \newphysicalconstant{planckc}%
694    {\symup{hc}}%
695    {2.0\timestento{-25}}{1.98644586\timestento{-25}}%
696    {\kilogram\usk\meter\tothethree\usk\second\totheinversetwo}%
697    [\joule\usk\meter]%
698    [\joule\usk\meter]%
699 \newphysicalconstant{protoncharge}%
700    {\symup{q_p}}%
701    {+\elementarychargeapproximatevalue}{+\elementarychargeprecisevalue}%
702    {\ampere\usk\second}%
703    [\coulomb]%
704    [\coulomb]%
705 \newphysicalconstant{protonCharge}%
706    {\symup{Q_p}}%
707    {+\elementarychargeapproximatevalue}{+\elementarychargeprecisevalue}%
708    {\ampere\usk\second}%
```

```
709    [\coulomb]%
710    [\coulomb]%
711  \newphysicalconstant{protonmass}%
712    {\symup{m_p}}%
713    {1.7\timestento{-27}}{1.672621898\timestento{-27}}%
714    {\kilogram}%
715  \newphysicalconstant{rydberg}%
716    {\symup{R_{\infty}}}%
717    {1.1\timestento{7}}{1.0973731568160\timestento{7}}%
718    {\meter\inverse}%
719  \newphysicalconstant{speedoflight}%
720    {\symup{c}}%
721    {3\timestento{8}}{2.99792458\timestento{8}}% % exact value
722    {\meter\usk\second\inverse}%
723    [\meter\per\second]%
724    [\meter\per\second]
725  \newphysicalconstant{stefanboltzmann}%
726    {\symup{\sigma}}%
727    {5.7\timestento{-8}}{5.670374\timestento{-8}}%
728    {\kilogram\usk\second\totheinversethree\usk\kelvin\totheinversefour}%
729    [\watt\per\meter\tothetwo\usk\kelvin\tothefour]%
730    [\watt\per\meter\tothetwo\usk\kelvin\tothefour]
731  \newphysicalconstant{sunearthdistance}%
732    {\symup{d_{SE}}}%
733    {1.5\timestento{11}}{1.496\timestento{11}}%
734    {\meter}%
735  \newphysicalconstant{sunmass}%
736    {\symup{M_{Sun}}}%
737    {2.0\timestento{30}}{1.98855\timestento{30}}%
738    {\kilogram}%
739  \newphysicalconstant{sunradius}%
740    {\symup{R_{Sun}}}%
741    {7.0\timestento{8}}{6.957\timestento{8}}%
742    {\meter}%
743  \newphysicalconstant{surfacegravfield}%
744    {\symup{g}}%
745    {9.8}{9.807}%
746    {\meter\usk\second\totheinversetwo}%
747    [\newton\per\kilogram]%
748    [\newton\per\kilogram]%
749  \newphysicalconstant{universalgrav}%
750    {\symup{G}}%
751    {6.7\timestento{-11}}{6.67430\timestento{-11}}%
752    {\meter\tothethree\usk\kilogram\inverse\usk\second\totheinversetwo}%
753    [\newton\usk\meter\tothetwo\per\kilogram\tothetwo]% % also \joule\usk\meter\per\kilogram\tothetwo
754    [\newton\usk\meter\tothetwo\per\kilogram\tothetwo]%
755  \newphysicalconstant{vacuumpermeability}%
756    {\symup{\mu_o}}%
757    {4\pi\timestento{-7}}{4\pi\timestento{-7}}% % as of 2018 no longer 4\pi\timestento{-7}
758    {\kilogram\usk\meter\usk\ampere\totheinversetwo\usk\second\totheinversetwo}%
759    [\henry\per\meter]%
760    [\tesla\usk\meter\per\ampere]%
761  \newphysicalconstant{vacuumpermittivity}%
762    {\symup{\epsilon_o}}%
763    {9\timestento{-12}}{8.854187817\timestento{-12}}%
764    {\ampere\tothetwo\usk\second\tothefour\usk\kilogram\inverse\usk\meter\totheinversethree}%
765    [\farad\per\meter]%
766    [\coulomb\tothetwo\per\newton\usk\meter\tothetwo]%
```

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

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

```
824      \footnotesize{\( \use:c {#1onlyderivedunits}    \)} &
825      \footnotesize{\( \use:c {#1onlyalternateunits} \)}
826    \end{tabular}
827   \end{center}
828 }%
829 \ExplSyntaxOff
```

$\mivector^{\rightarrow P.\,37}$ is a workhorse command. Orginal code provided by `@egreg`.
See https://tex.stackexchange.com/a/39054/218142.

```
830 \ExplSyntaxOn
831 \NewDocumentCommand{\mivector}{ O{,} m o }%
832 {%
833    \mi_vector:nn { #1 } { #2 }%
834    \IfValueT{#3}{\,{#3}}%
835 }%
836 \seq_new:N \l__mi_list_seq
837 \cs_new_protected:Npn \mi_vector:nn #1 #2
838 {%
839   \ensuremath{%
840      \seq_set_split:Nnn \l__mi_list_seq { , } { #2 }
841      \int_compare:nF { \seq_count:N \l__mi_list_seq = 1 } { \left\langle }
842      \seq_use:Nnnn \l__mi_list_seq { #1 } { #1 } { #1 }
843      \int_compare:nF { \seq_count:N \l__mi_list_seq = 1 } { \right\rangle }
844   }%
845 }%
846 \ExplSyntaxOff
```

4 The **mandistudent** Package

mandi comes with an accessory package mandistudent, which provides a collection of commands physics students can use for writing problem solutions. 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 v3.0.0 dated 2021-08-21 and is a stable build.

4.1 Traditional Vector Notation

\vec{⟨*symbol*⟩}[⟨*labels*⟩]   (use this variant for boldface notation)
\vec*{⟨*symbol*⟩}[⟨*labels*⟩]   (use this variant for arrow notation)

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

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

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

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

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

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

$$\widehat{\boldsymbol{p}}$$
$$\widehat{\boldsymbol{p}}_2$$
$$\widehat{\boldsymbol{p}}^{\text{ball}}$$
$$\widehat{\boldsymbol{p}}_{\text{final}}$$
$$\widehat{\boldsymbol{p}}^{\text{ball}}_{\text{final}}$$
$$\widehat{\boldsymbol{p}}^{\text{final}}_{\text{ball}}$$
$$\widehat{p}$$

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

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

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

$$\mathbf{0}$$
$$\vec{0}$$

\changein

Semantic alias for **\Delta**.

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

$$\Delta t$$
$$\Delta \boldsymbol{p}$$

\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.

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

$$\| \cdot \|$$

$$\|\boldsymbol{a}\|$$

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

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

```
\[ \singlebars{} \]
\[ \singlebars{x} \]
\[ \singlebars*{\frac{x}{3}} \]
\[ \singlebars[\Bigg]{\frac{x}{3}} \]
```

$$| \cdot |$$

$$|x|$$

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

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

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

$$\langle \cdot \rangle$$

$$\langle \boldsymbol{a} \rangle$$

$$\left\langle\frac{\boldsymbol{a}}{3}\right\rangle$$

$$\left\langle\frac{\boldsymbol{a}}{3}\right\rangle$$

```
\[ \parentheses{} \]
\[ \parentheses{x} \]
\[ \parentheses*{\frac{x}{3}} \]
\[ \parentheses[\Bigg]{\frac{x}{3}} \]
```

$$(\cdot)$$

$$(x)$$

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

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

```
\[ \squarebrackets{} \]
\[ \squarebrackets{x} \]
\[ \squarebrackets*{\frac{x}{3}} \]
\[ \squarebrackets[\Bigg]{\frac{x}{3}} \]
```

$$[\,\cdot\,]$$

$$[x]$$

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

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

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

$$\{\,\cdot\,\}$$

$$\{x\}$$

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

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

`\magnitude[`⟨*size*⟩`]{`⟨*quantity*⟩`}` (alias for double bars)
`\magnitude*[`⟨*size*⟩`]{`⟨*quantity*⟩`}` (alias for double bars for fractions)
`\norm[`⟨*size*⟩`]{`⟨*quantity*⟩`}` (alias for double bars)
`\norm*[`⟨*size*⟩`]{`⟨*quantity*⟩`}` (alias for double bars for fractions)
`\absolutevalue[`⟨*size*⟩`]{`⟨*quantity*⟩`}` (alias for single bars)
`\absolutevalue*[`⟨*size*⟩`]{`⟨*quantity*⟩`}` (alias for single bars for fractions)

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

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

$$\|\boldsymbol{p}\|$$

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

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

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

`\parallelto`
`\perpendicularto`

Commands for geometric relationships, mainly intended for subscripts.

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

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

4.2   Problems and Annotated Problem Solutions

`\begin{physicsproblem}{`⟨*title*⟩`}`   (use this variant for vertical lists)
    ⟨*problem*⟩
`\end{physicsproblem}`
`\begin{physicsproblem*}{`⟨*title*⟩`}`   (use this variant for in-line lists)
    ⟨*problem*⟩
`\end{physicsproblem*}`
`\begin{parts}{`⟨*title*⟩`}`   (provides problem parts)
    ⟨*problem*⟩
`\end{parts}`

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

\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.

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

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

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

$$x = y + z \tag{1}$$
$$z = x - y \tag{2}$$
$$y = x - z \tag{3}$$

$$x = y + z$$
$$z = x - y$$
$$y = x - z$$

`\reason``{`⟨*reason*⟩`}`

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

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

$$x = y + z \qquad \text{This is a reason.} \qquad (4)$$
$$z = x - y \qquad \text{This is a reason too.} \qquad (5)$$
$$y = x - z \qquad \text{final answer} \qquad (6)$$

$$x = y + z \qquad \text{This is a reason.}$$
$$z = x - y \qquad \text{This is a reason too.}$$
$$y = x - z \qquad \text{final answer}$$

When writing solutions, remember that the **physicssolution**$^{\rightarrow\,\text{P.59}}$ environment is *only* for mathematical content, not textual content or explanations.

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

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

N 2021-02-06   **\hilite**[⟨*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 +
                  (\Delta z)^2 \\
  (\Delta s)^2 &= \hilite{-(\Delta t)^2 + (\Delta x)^2}[rounded rectangle] +
                  (\Delta y)^2 + (\Delta z)^2 \\
  (\Delta s)^2 &= \hilite{-(\Delta t)^2 + (\Delta x)^2}[rectangle] +
                  (\Delta y)^2 + (\Delta z)^2 \\
  (\Delta s)^2 &= \hilite{-(\Delta t)^2 + (\Delta x)^2}[ellipse] +
                  (\Delta y)^2 + (\Delta z)^2 \\
  (\Delta s)^{\hilite{2}[circle]} &= \hilite[green]{-}[circle]
                (\Delta t)^{\hilite[cyan]{2}[circle]}+
                (\Delta x)^{\hilite[orange]{2}[circle]} +
                (\Delta y)^{\hilite[blue!50]{2}[circle]} +
                (\Delta z)^{\hilite[violet!45]{2}[circle]}
\end{align*}
```

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

```
\begin{align*}
  \Delta\vec{p} &= \vec{F}_{\sumup{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*}
```

$$\Delta\boldsymbol{p} = \boldsymbol{F}_{\mathrm{net}}\Delta t$$
$$\Delta\boldsymbol{p} = \boldsymbol{F}_{\mathrm{net}}\Delta t$$
$$\Delta\boldsymbol{p} = \boldsymbol{F}_{\mathrm{net}}\Delta t$$
$$\Delta\boldsymbol{p} = \boldsymbol{F}_{\mathrm{net}}\Delta t$$
$$\Delta\boldsymbol{p} = \boldsymbol{F}_{\mathrm{net}}\Delta t$$
$$\Delta\boldsymbol{p} = \boldsymbol{F}_{\mathrm{net}}\Delta t$$

\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 62.

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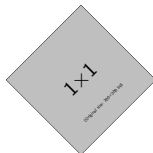

Figure 2: Image shown 20 percent actual size and rotated.

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

Figure 2 is nice. It's captioned Image shown 20 percent actual size and rotated and is on page 62.

4.3   Coordinate-Free and Index Notation

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

\colvec[⟨*delimiter*⟩]{⟨$c_1, \ldots, c_n$⟩}
\rowvec[⟨*delimiter*⟩]{⟨$c_1, \ldots, c_n$⟩}

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.

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

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

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

$$\begin{pmatrix} x^0 \\ x^1 \\ x^2 \\ x^3 \end{pmatrix}$$

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

\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

r

r

\valence{⟨*index*⟩}{⟨*index*⟩}
\valence*{⟨*index*⟩}{⟨*index*⟩}

Typesets tensor valence. The starred variant typesets it horizontally.

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

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

\contraction{⟨*slot,slot*⟩}
\contraction*{⟨*slot,slot*⟩}

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

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

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

\slot[⟨*vector*⟩]
\slot*[⟨*vector*⟩]

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

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

$$(\underline{})$$
$$(\underline{\boldsymbol{a}})$$
$$( )$$
$$(\boldsymbol{a})$$

\diff

Intelligent differential (exterior derivative) operator.

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

$$\int x\,dx$$

$$\int x\,\mathrm{d}x$$

$$\int x\,\mathbf{d}x$$

4.4 GlowScript and VPython Program Listings

[GlowScript][3] and [VPython][4] are programming environments (both use [Python]) frequently used in introductory physics to introduce students for modeling physical systems. mandi makes including code listings very simple for students.

4.5 The `glowscriptblock` Environment

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

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

---

[3]https://glowscript.org
[4]https://vpython.org

```
\begin{glowscriptblock}(tinyurl.com/y3lnqyn3){A \texttt{GlowScript} Program}
GlowScript 3.0 vpython

scene.width = 400
scene.height = 760
# constants and data
g = 9.8        # m/s^2
mball = 0.03  # kg
Lo = 0.26      # m
ks = 1.8       # N/m
deltat = 0.01 # s

# objects (origin is at ceiling)
ceiling = box(pos=vector(0,0,0), length=0.2, height=0.01,
              width=0.2)
ball = sphere(pos=vector(0,-0.3,0),radius=0.025,
              color=color.orange)
spring = helix(pos=ceiling.pos, axis=ball.pos-ceiling.pos,
                color=color.cyan,thickness=0.003,coils=40,
                radius=0.010)

# initial values
pball = mball * vector(0,0,0)      # kg m/s
Fgrav = mball * g * vector(0,-1,0) # N
t = 0

# improve the display
scene.autoscale = False        # turn off automatic camera zoom
scene.center = vector(0,-Lo,0) # move camera down
scene.waitfor('click')         # wait for a mouse click

# initial calculation loop
# calculation loop
while t < 10:
    rate(100)
    # we need the stretch
    s = mag(ball.pos) - Lo
    # we need the spring force
    Fspring = ks * s * -norm(spring.axis)
    Fnet = Fgrav + Fspring
    pball = pball + Fnet * deltat
    ball.pos = ball.pos + (pball / mball) * deltat
    spring.axis = ball.pos - ceiling.pos
    t = t + deltat
\end{glowscriptblock}
```

GlowScript Program 1: A GlowScript Program

```
1   GlowScript 3.0 vpython
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
```

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

- -

GlowScript program 1 is nice. It's called A GlowScript Program and is on page 66.

4.6   The `vpythonfile` Command

\vpythonfile[⟨*options*⟩]{⟨*file*⟩}{⟨*caption*⟩}

Command to load and typeset a `VPython` program. The file is read from {⟨*file*⟩}. Clicking anywhere in the code window can optionally open a link, passed as an option, in the default browser. A caption is mandatory, and a label is internally generated. The listing always begins on a new page. A URL shortening utility is recommended to keep the URL from getting unruly. For convenience, `https://` is automatically prepended to the URL and can thus be omitted.

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

VPython Program 1: A VPython Program

```python
from vpython import *

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
```

```
\VPython\ program \ref{vp:1} is nice.
It's called \nameref{vp:1} and is on page \pageref{vp:1}.
```
- -

VPython program 1 is nice. It's called A VPython Program and is on page 68.

4.7 The `glowscriptinline` and `vpythoninline` Commands

\glowscriptinline{⟨*GlowScript code*⟩}
\vpythoninline{⟨*VPython code*⟩}

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

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

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

4.8 **mandistudent** Source Code

Define the package version and date for global use, exploiting the fact that in a .sty file there is now no need for `\makeatletter` and `\makeatother`. This simplifies defining internal commands, with @ in the name, that are not for the user to know about.

```
1 \def\mandistudent@version{\mandi@version}
2 \def\mandistudent@date{\mandi@date}
3 \NeedsTeXFormat{LaTeX2e}[2020-02-02]
4 \DeclareRelease{v3.0.0}{2021-08-21}{mandistudent.sty}
5 \DeclareCurrentRelease{v\mandi@version}{\mandi@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{pgfopts}           % 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 \RequirePackage{hyperref}          % load last
25 \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 LaTeX kernel. Because unicode-math is required, all documents using mandi must be compiled with an engine that supports Unicode. We recommend LuaLaTeX.

```
26 \unimathsetup{math-style=ISO}
27 \unimathsetup{warnings-off={mathtools-colon,mathtools-overbracket}}
28 %
29 % Use normal math letters from Latin Modern Math for familiarity with
30 % textbooks.
31 %
32 %     \begin{macrocode}
33 \setmathfont[Scale=MatchLowercase]
34   {Latin Modern Math}    % default math font; better J
```

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

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

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

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

Borrow `mathscr` and `mathbfscr` from XITS Math.
See https://tex.stackexchange.com/a/120073/218142.

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

Get original and bold `mathcal` fonts.
See .

```
40 \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.

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

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

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

```
126 \DeclareFontFamily{U}{esvect}{}
127 \DeclareFontShape{U}{esvect}{m}{n}{%
128   <-5.5> vect5
129   <5.5-6.5> vect6
130   <6.5-7.5> vect7
131   <7.5-8.5> vect8
132   <8.5-9.5> vect9
133   <9.5-> vect10
134 }{}%
```

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

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

A better, intelligent coordinate-free \vec[→P. 54] 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.

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

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

```
157 \NewDocumentCommand{\dirvec}{ s m e{_^} }{%
158     \widehat{\makebox*{\(w\)}{\ensuremath{%
159       \IfBooleanTF {#1}
160         {%
161           #2
162         }%
163         {%
164           \symbfit{#2}
165         }%
166       }%
167     }%
168     }%
169     \sb{\IfValueT{#3}{#3}\vphantom{\smash[b]{|}}}}
170     \sp{\IfValueT{#4}{\,#4}\vphantom{\smash[t]{\big|}}}}
171 }%
```

The zero vector.

```
172 \NewDocumentCommand{\zerovec}{ s }{%
173   \IfBooleanTF {#1}
174     {\vv{0}}%
175     {\symbfup{0}}%
176 }%
```

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

```
177 \ExplSyntaxOn
178 \NewDocumentCommand{\colvec}{ O{,} m }{%
179   \vector_main:nnnn { p } { \\ } { #1 } { #2 }
180 }%
181 \NewDocumentCommand{\rowvec}{ O{,} m }{%
182   \vector_main:nnnn { p } { & } { #1 } { #2 }
183 }%
184 \seq_new:N \l__vector_arg_seq
185 \cs_new_protected:Npn \vector_main:nnnn #1 #2 #3 #4 {%
186   \seq_set_split:Nnn \l__vector_arg_seq { #3 } { #4 }
187   \begin{#1NiceMatrix}[r]
188     \seq_use:Nnnn \l__vector_arg_seq { #2 } { #2 } { #2 }
```

```
189    \end{#1NiceMatrix}
190 }%
191 \ExplSyntaxOff
```

Students always need this symbol.

```
192 \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.

```
193 \DeclarePairedDelimiterX{\doublebars}[1]{\lVert}{\rVert}{\ifblank{#1}{\:\cdot\:}{#1}}
194 \DeclarePairedDelimiterX{\singlebars}[1]{\lvert}{\rvert}{\ifblank{#1}{\:\cdot\:}{#1}}
195 \DeclarePairedDelimiterX{\anglebrackets}[1]{\langle}{\rangle}{\ifblank{#1}{\:\cdot\:}{#1}}
196 \DeclarePairedDelimiterX{\parentheses}[1]{(}{)}{\ifblank{#1}{\:\cdot\:}{#1}}
197 \DeclarePairedDelimiterX{\squarebrackets}[1]{\lbrack}{\rbrack}{\ifblank{#1}{\:\cdot\:}{#1}}
198 \DeclarePairedDelimiterX{\curlybraces}[1]{\lbrace}{\rbrace}{\ifblank{#1}{\:\cdot\:}{#1}}
```

Some semantic aliases. Because of the way \vec^{→P. 54} and \dirvec^{→P. 54} are defined, I reluctantly decided not to implement a \magvec command. It would require accounting for too mamy options. So \magnitude^{→P. 57} is the new solution.

```
199 \NewDocumentCommand{\magnitude}{}{\doublebars}
200 \NewDocumentCommand{\norm}{}{\doublebars}
201 \NewDocumentCommand{\absolutevalue}{}{\singlebars}
```

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

```
202 \NewDocumentCommand{\parallelto}{}
203   {\mkern3mu\vphantom{\perp}\vrule depth 0pt\mkern2mu\vrule depth 0pt\mkern3mu}
204 \NewDocumentCommand{\perpendicularto}{}{\perp}
```

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

```
205 \NewDocumentEnvironment{physicsproblem}{ m }{%
206   \newpage%
207   \section*{#1}%
208   \newlist{parts}{enumerate}{2}%
209   \setlist[parts]{label=\bfseries(\alph*)}}%
210   {}%
211 \NewDocumentEnvironment{physicsproblem*}{ m }{%
212   \newpage%
213   \section*{#1}%
214   \newlist{parts}{enumerate*}{2}%
215   \setlist[parts]{label=\bfseries(\alph*)}}%
216   {}%
217 \NewDocumentCommand{\problempart}{}{\item}%
```

An environment for problem solutions.

```
218 \NewDocumentEnvironment{physicssolution}{ +b }{%
219   % Make equation numbering consecutive through the document.
220   \begin{align}
221     #1
222   \end{align}
223 }{}%
224 \NewDocumentEnvironment{physicssolution*}{ +b }{%
225   % Make equation numbering consecutive through the document.
226   \begin{align*}
227     #1
228   \end{align*}
229 }{}%
```

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

```
230 \NewDocumentCommand{\reason}{ O{4cm} m }
231   {&&\begin{minipage}{#1}\raggedright\small #2\end{minipage}}
```

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

Original code by anonymous user @abcdefg, modified by me.

See https://texample.net/tikz/examples/beamer-arrows/.

See also https://tex.stackexchange.com/a/406084/218142.

See also https://tex.stackexchange.com/a/570858/218142.

See also https://tex.stackexchange.com/a/570789/218142.

See also https://tex.stackexchange.com/a/79659/218142.

See also https://tex.stackexchange.com/q/375032/218142.

See also https://tex.stackexchange.com/a/571744/218142

```
232 \newcounter{tikzhighlightnode}
233 \NewDocumentCommand{\hilite}{ O{magenta!60} m O{rectangle} }{%
234   \stepcounter{tikzhighlightnode}%
235   \tikzmarknode{highlighted-node-\number\value{tikzhighlightnode}}{#2}%
236   \edef\temp{%
237     \noexpand\AddToShipoutPictureBG{%
238       \noexpand\begin{tikzpicture}[overlay,remember picture]%
239       \noexpand\iftikzmarkoncurrentpage{highlighted-node-\number\value{tikzhighlightnode}}%
240        \noexpand\node[inner sep=1.0pt,fill=#1,#3,fit=(highlighted-node-\number\value{tikzhighlightnode})]{};%
241       \noexpand\fi
242       \noexpand\end{tikzpicture}%
243     }%
244   }%
245   \temp%
246 }%
```

A simplified command for importing images.

```
247 \NewDocumentCommand{\image}{ O{scale=1} m m m }{%
248   \begin{figure}[ht!]
249     \begin{center}%
250       \includegraphics[#1]{#2}%
251     \end{center}%
252     \caption{#3}%
253     \label{#4}%
254   \end{figure}%
255 }%
```

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.

```
256 \NewDocumentCommand{\veccomp}{ s m }{%
257   % Consider renaming this to \vectorsym.
258   \IfBooleanTF{#1}
259   {%
260     \symnormal{#2}%
261   }%
262   {%
263     \symbfit{#2}%
264   }%
265 }%
266 \NewDocumentCommand{\tencomp}{ s m }{%
267   % Consider renaming this to \tensororsym.
268   \IfBooleanTF{#1}
269   {%
270     \symsfit{#2}%
271   }%
272   {%
273     \symbfsfit{#2}
274   }%
275 }%
```

Command to typeset tensor valence.

```
276 \NewDocumentCommand{\valence}{ s m m }{%
277   \IfBooleanTF{#1}
278     {(#2,#3)}
279     {\binom{#2}{#3}}
280 }%
```

Intelligent notation for contraction on pairs of slots.

```
281 \NewDocumentCommand{\contraction}{ s m }{%
282   \IfBooleanTF{#1}
283   {\mathsf{C}}%
284   {\symbb{C}}%
285   _{#2}
286 }%
```

Intelligent slot command for coordinate-free tensor notation.

```
287 \NewDocumentCommand{\slot}{ s d[] }{%
288   % d[] must be used because of the way consecutive optional
289   %  arguments are handled. See xparse docs for details.
290   \IfBooleanTF{#1}
291   {%
292     \IfValueTF{#2}
293     {% Insert a vector, but don't show the slot.
294       \smash{\makebox[1.5em]{\ensuremath{#2}}}
295     }%
296     {% No vector, no slot.
297       \smash{\makebox[1.5em]{\ensuremath{}}}
298     }%
299   }%
300   {%
301     \IfValueTF{#2}
302     {% Insert a vector and show the slot.
303       \underline{\smash{\makebox[1.5em]{\ensuremath{#2}}}}
304     }%
305     {% No vector; just show the slot.
306       \underline{\smash{\makebox[1.5em]{\ensuremath{}}}}
307     }%
308   }%
309 }%
```

Intelligent differential (exterior derivative) operator.

```
310 \NewDocumentCommand{\diff}{ s }{%
311   \mathop{}\!
312   \IfBooleanTF{#1}
313   {\symbfsfup{d}}%
314   {\symsfup{d}}%
315 }%
```

Here is a clever way to color digits in program listsings thanks to Ulrike Fischer.
See https://tex.stackexchange.com/a/570717/218142.

```
316 \directlua{%
317 luaotfload.add_colorscheme("colordigits",
318   {["8000FF"] = {"one","two","three","four","five","six","seven","eight","nine","zero"}})
319 }%
320 \newfontfamily\colordigits{DejaVuSansMono}[RawFeature={color=colordigits}]
```

Set up a color scheme and a new code environment for listings. The new colors are more restful on the eye. All listing commands now use tcolorbox.
See https://tex.stackexchange.com/a/529421/218142.

```
321 \newfontfamily{\gsfontfamily}{DejaVuSansMono}     % new font for listings
322 \definecolor{gsbggray}     {rgb}{0.90,0.90,0.90} % background gray
323 \definecolor{gsgray}       {rgb}{0.30,0.30,0.30} % gray
324 \definecolor{gsgreen}      {rgb}{0.00,0.60,0.00} % green
325 \definecolor{gsorange}     {rgb}{0.80,0.45,0.12} % orange
326 \definecolor{gspeach}      {rgb}{1.00,0.90,0.71} % peach
327 \definecolor{gspearl}      {rgb}{0.94,0.92,0.84} % pearl
328 \definecolor{gsplum}       {rgb}{0.74,0.46,0.70} % plum
329 \lstdefinestyle{vpython}{%                        % style for listings
330   backgroundcolor=\color{gsbggray},%              % background color
331   basicstyle=\colordigits\footnotesize,%          % default style
332   breakatwhitespace=true%                         % break at whitespace
333   breaklines=true,%                               % break long lines
334   captionpos=b,%                                  % position caption
335   classoffset=1,%                                 % STILL DON'T UNDERSTAND THIS
336   commentstyle=\color{gsgray},%                   % font for comments
337   deletekeywords={print},%                        % delete keywords from the given language
338   emph={self,cls,@classmethod,@property},%        % words to emphasize
339   emphstyle=\color{gsorange}\itshape,%            % font for emphasis
340   escapeinside={(*@}{@*)},%                        % add LaTeX within your code
341   frame=tb,%                                       % frame style
342   framerule=2.0pt,%                                % frame thickness
343   framexleftmargin=5pt,%                           % extra frame left margin
344   %identifierstyle=\sffamily,%                      % style for identifiers
345   keywordstyle=\gsfontfamily\color{gsplum},%       % color for keywords
346   language=Python,%                                % select language
347   linewidth=\linewidth,%                           % width of listings
348   morekeywords={%                                  % VPython/GlowScript specific keywords
349     __future__,abs,acos,align,ambient,angle,append,append_to_caption,%
350     append_to_title,arange,arrow,asin,astuple,atan,atan2,attach_arrow,%
351     attach_trail,autoscale,axis,background,billboard,bind,black,blue,border,%
352     bounding_box,box,bumpaxis,bumpmap,bumpmaps,camera,canvas,caption,capture,%
353     ceil,center,clear,clear_trail,click,clone,CoffeeScript,coils,color,combin,%
354     comp,compound,cone,convex,cos,cross,curve,cyan,cylinder,data,degrees,del,%
355     delete,depth,descender,diff_angle,digits,division,dot,draw_complete,%
356     ellipsoid,emissive,end_face_color,equals,explog,extrusion,faces,factorial,%
357     False,floor,follow,font,format,forward,fov,frame,gcurve,gdisplay,gdots,%
358     get_library,get_selected,ghbars,global,GlowScript,graph,graphs,green,gvbars,%
359     hat,headlength,headwidth,height,helix,hsv_to_rgb,index,interval,keydown,%
360     keyup,label,length,lights,line,linecolor,linewidth,logx,logy,lower_left,%
361     lower_right,mag,mag2,magenta,make_trail,marker_color,markers,material,%
362     max,min,mouse,mousedown,mousemove,mouseup,newball,norm,normal,objects,%
363     offset,one,opacity,orange,origin,path,pause,pi,pixel_to_world,pixels,plot,%
364     points,pos,pow,pps,print,print_function,print_options,proj,purple,pyramid,%
365     quad,radians,radius,random,rate,ray,read_local_file,readonly,red,redraw,%
366     retain,rgb_to_hsv,ring,rotate,round,scene,scroll,shaftwidth,shape,shapes,%
367     shininess,show_end_face,show_start_face,sign,sin,size,size_units,sleep,%
368     smooth,space,sphere,sqrt,start,start_face_color,stop,tan,text,textpos,%
369     texture,textures,thickness,title,trail_color,trail_object,trail_radius,%
370     trail_type,triangle,trigger,True,twist,unbind,up,upper_left,upper_right,%
371     userpan,userspin,userzoom,vec,vector,vertex,vertical_spacing,visible,%
372     visual,vpython,VPython,waitfor,white,width,world,xtitle,yellow,yoffset,%
373     ytitle%
374   },%
375   morekeywords={print,None,TypeError},%     % additional keywords
376   morestring=[b]{"""},%                      % treat triple quotes as strings
377   numbers=left,%                             % where to put line numbers
378   numbersep=10pt,%                           % how far line numbers are from code
379   numberstyle=\bfseries\tiny,%               % set to 'none' for no line numbers
```

```
380   showstringspaces=false,%                      % show spaces in strings
381   showtabs=false,%                              % show tabs within strings
382   stringstyle=\gsfontfamily\color{gsgreen},% % color for strings
383   upquote=true,%                               % how to typeset quotes
384 }%
```

Introduce a new, more intelligent glowscriptblock^{→P. 64} environment.

```
385 \NewTCBListing[auto counter,list inside=gsprogs]{glowscriptblock}
386   { O{} D(){glowscript.org} m }{%
387   breakable,%
388   center,%
389   code = \newpage,%
390   %derivpeach,%
391   enhanced,%
392   hyperurl interior = https://#2,%
393   label = {gs:\thetcbcounter},%
394   left = 8mm,%
395   list entry = \thetcbcounter~~~~~#3,%
396   listing only,%
397   listing style = vpython,%
398   nameref = {#3},%
399   title = \texttt{GlowScript} Program \thetcbcounter: #3,%
400   width = 0.9\textwidth,%
401   {#1},
402 }%
```

A new command for generating a list of GlowScript programs.

```
403 \NewDocumentCommand{\listofglowscriptprograms}{}{\tcblistof[\section*]{gsprogs}
404   {List of \texttt{GlowScript} Programs}}%
```

Introduce a new, more intelligent \vpythonfile^{→P. 67} command.

```
405 \NewTCBInputListing[auto counter,list inside=vpprogs]{\vpythonfile}
406   { O{} m m }{%
407   breakable,%
408   center,%
409   code = \newpage,%
410   %derivgray,%
411   enhanced,%
412   hyperurl interior = https://,%
413   label = {vp:\thetcbcounter},%
414   left = 8mm,%
415   list entry = \thetcbcounter~~~~~#3,%
416   listing file = {#2},%
417   listing only,%
418   listing style = vpython,%
419   nameref = {#3},%
420   title = \texttt{VPython} Program \thetcbcounter: #3,%
421   width = 0.9\textwidth,%
422   {#1},%
423 }%
```

A new command for generating a list of VPython programs.

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

Introduce a new \glowscriptinline^{→P. 69} command.

```
426 \DeclareTotalTCBox{\glowscriptinline}{ m }{%
427   bottom = 0pt,%
428   bottomrule = 0.0mm,%
```

```
429   boxsep = 1.0mm,%
430   colback = gsbggray,%
431   colframe = gsbggray,%
432   left = 0pt,%
433   leftrule = 0.0mm,%
434   nobeforeafter,%
435   right = 0pt,%
436   rightrule = 0.0mm,%
437   sharp corners,%
438   tcbox raise base,%
439   top = 0pt,%
440   toprule = 0.0mm,%
441 }{\lstinline[style = vpython]{#1}}%
```

Define \vpythoninline$^{\rightarrow\text{P. }69}$, a semantic alias for `VPython` in-line listings.

```
442 \NewDocumentCommand{\vpythoninline}{}{\glowscriptinline}%
```

5   The **mandiexp** Package

mandi comes with an accessory package mandiexp which includes commands specific to *Matter & Interactions.*[5] 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 v3.0.0 dated 2021-08-21 and is a stable build.

5.1   The Fundamenal Principles

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

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

---

[5]See *Matter & Interactions* and https://matterandinteractions.org/ for details.

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

$$\Delta \boldsymbol{p}_{\text{sys}}$$
$$\boldsymbol{F}_{\text{sys,net}}\, \Delta t$$
$$\boldsymbol{p}_{\text{sys,final}}$$
$$\boldsymbol{p}_{\text{sys,initial}} + \boldsymbol{F}_{\text{sys,net}}\, \Delta t$$
$$\Delta \boldsymbol{p}_{\text{sys}} = \boldsymbol{F}_{\text{sys,net}}\, \Delta t$$
$$\boldsymbol{p}_{\text{sys,final}} = \boldsymbol{p}_{\text{sys,initial}} + \boldsymbol{F}_{\text{sys,net}}\, \Delta t$$
$$\Delta \vec{p}_{\text{sys}}$$
$$\vec{F}_{\text{sys,net}}\, \Delta t$$
$$\vec{p}_{\text{sys,final}}$$
$$\vec{p}_{\text{sys,initial}} + \vec{F}_{\text{sys,net}}\, \Delta t$$
$$\Delta \vec{p}_{\text{sys}} = \vec{F}_{\text{sys,net}}\, \Delta t$$
$$\vec{p}_{\text{sys,final}} = \vec{p}_{\text{sys,initial}} + \vec{F}_{\text{sys,net}}\, \Delta t$$

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

Variants of command for typesetting the energy principle.

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

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

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

\angularmomentumprincipleupdate* (update form, arrow vectors)

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

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

5.2 Other Expressions

\energyof{⟨*label*⟩}[⟨*label*⟩]

Generic symbol for the energy of some entity.

\(\energyof{\symup{electron}} \) \\	E_{electron}
\(\energyof{\symup{electron}}[\symup{final}] \)	$E_{\text{electron,final}}$

\systemenergy[⟨*label*⟩]

Symbol for system energy.

\(\systemenergy \) \\	E_{sys}
\(\systemenergy[\symup{final}] \)	$E_{\text{sys,final}}$

\particleenergy[⟨*label*⟩]

Symbol for particle energy.

\(\particleenergy \) \\	E_{particle}
\(\particleenergy[\symup{final}] \)	$E_{\text{particle,final}}$

\restenergy[⟨*label*⟩]

Symbol for rest energy.

```
\( \restenergy \) \\
\( \restenergy[\symup{final}] \)
```
E_{rest}
$E_{\text{rest,final}}$

\internalenergy[⟨*label*⟩]

Symbol for internal energy.

```
\( \internalenergy \) \\
\( \internalenergy[\symup{final}] \)
```
E_{internal}
$E_{\text{internal,final}}$

\chemicalenergy[⟨*label*⟩]

Symbol for chemical energy.

```
\( \chemicalenergy \) \\
\( \chemicalenergy[\symup{final}] \)
```
E_{chem}
$E_{\text{chem,final}}$

\thermalenergy[⟨*label*⟩]

Symbol for thermal energy.

```
\( \thermalenergy \) \\
\( \thermalenergy[\symup{final}] \)
```
E_{therm}
$E_{\text{therm,final}}$

\photonenergy[⟨*label*⟩]

Symbol for photon energy.

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

\translationalkineticenergy[⟨*label*⟩]
\translationalkineticenergy*[⟨*label*⟩]

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

```
\( \translationalkineticenergy \)                    \\
\( \translationalkineticenergy[\symup{initial}] \) \\
\( \translationalkineticenergy* \)                   \\
\( \translationalkineticenergy*[\symup{initial}] \)
```
K_{trans}
$K_{\text{trans,initial}}$
E_{K}
$E_{\text{K,initial}}$

\rotationalkineticenergy[⟨*label*⟩]
\rotationalkineticenergy*[⟨*label*⟩]

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

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

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

\vibrationalkineticenergy[⟨*label*⟩]
\vibrationalkineticenergy*[⟨*label*⟩]

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

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

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

\gravitationalpotentialenergy[⟨*label*⟩]

Symbol for gravitational potential energy.

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

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

\electricpotentialenergy[⟨*label*⟩]

Symbol for electric potential energy.

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

U_{e}
$U_{\mathrm{e,final}}$

\springpotentialenergy[⟨*label*⟩]

Symbol for spring potential energy.

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

U_{s}
$U_{\mathrm{s,final}}$

5.3 mandiexp Source Code

Definine the package version and date for global use, exploiting the fact that in a .sty file there is now no need for \makeatletter and \makeatother. This simplifies defining internal commands, with @ in the name, that are not for the user to know about.

```
1 \def\mandiexp@version{\mandi@version}
2 \def\mandiexp@date{\mandi@date}
3 \NeedsTeXFormat{LaTeX2e}[2020-02-02]
4 \DeclareRelease{v3.0.0}{2021-08-21}{mandiexp.sty}
5 \DeclareCurrentRelease{v\mandi@version}{\mandi@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 %
11 \typeout{}%
12 \typeout{mandiexp: You are using mandiexp \mandiexpversion.}
13 \typeout{mandiexp: This package requires LuaLaTeX.}%
14 \typeout{}%
15 %
16 % Commands specific to Matter & Interactions
17 % The momentum principle
18 \NewDocumentCommand{\lhsmomentumprinciple}{ s }{%
19   \Delta
20   \IfBooleanTF{#1}%
21     {\vec*{p}}%
22     {\vec{p}}%
23   _{\symup{sys}}%
24 }%
25 \NewDocumentCommand{\rhsmomentumprinciple}{ s }{%
26   \IfBooleanTF{#1}%
27     {\vec*{F}}%
28     {\vec{F}}%
29   _{\symup{sys,net}}\,\Delta t%
30 }%
31 \NewDocumentCommand{\lhsmomentumprincipleupdate}{ s }{%
32   \IfBooleanTF{#1}%
33     {\vec*{p}}%
34     {\vec{p}}%
35   _{\symup{sys,final}}%
36 }%
37 \NewDocumentCommand{\rhsmomentumprincipleupdate}{ s }{%
38   \IfBooleanTF{#1}%
39     {\vec*{p}}%
40     {\vec{p}}%
41   _{\symup{sys,initial}}+%
42   \IfBooleanTF{#1}%
43     {\vec*{F}}%
44     {\vec{F}}%
45   _{\symup{sys,net}}\,\Delta t%
46 }%
47 \NewDocumentCommand{\momentumprinciple}{ s }{%
48   \IfBooleanTF{#1}%
49     {\lhsmomentumprinciple* = \rhsmomentumprinciple*}%
50     {\lhsmomentumprinciple = \rhsmomentumprinciple}%
51 }%
```

```latex
52 \NewDocumentCommand{\momentumprincipleupdate}{ s }{%
53   \IfBooleanTF{#1}%
54     {\lhsmomentumprincipleupdate* = \rhsmomentumprincipleupdate*}%
55     {\lhsmomentumprincipleupdate = \rhsmomentumprincipleupdate}%
56 }%
57 % The momentum principle
58 \NewDocumentCommand{\lhsenergyprinciple}{}{%
59   \Delta E_{\symup{sys}}%
60 }%
61 \NewDocumentCommand{\rhsenergyprinciple}{ O{} }{%
62   W_{\symup{ext}}#1%
63 }%
64 \NewDocumentCommand{\lhsenergyprincipleupdate}{}{%
65   E_{\symup{sys,final}}%
66 }%
67 \NewDocumentCommand{\rhsenergyprincipleupdate}{ O{} }{%
68   E_{\symup{sys,initial}}+%
69   W_{\symup{ext}}#1%
70 }%
71 \NewDocumentCommand{\energyprinciple}{ O{} }{%
72   \lhsenergyprinciple = \rhsenergyprinciple[#1]%
73 }%
74 \NewDocumentCommand{\energyprincipleupdate}{ O{} }{%
75   \lhsenergyprincipleupdate = \rhsenergyprincipleupdate[#1]%
76 }%
77 % The angular momentum principle
78 \NewDocumentCommand{\lhsangularmomentumprinciple}{ s }{%
79   \Delta
80   \IfBooleanTF{#1}%
81     {\vec*{L}}%
82     {\vec{L}}%
83   _{A\symup{,sys,net}}%
84 }%
85 \NewDocumentCommand{\rhsangularmomentumprinciple}{ s }{%
86   \IfBooleanTF{#1}%
87     {\vec*{\tau}}%
88     {\vec{\tau}}%
89   _{A\symup{,sys,net}}\,\Delta t%
90 }%
91 \NewDocumentCommand{\lhsangularmomentumprincipleupdate}{ s }{%
92   \IfBooleanTF{#1}%
93     {\vec*{L}}%
94     {\vec{L}}%
95   _{A,\symup{sys,final}}%
96 }%
97 \NewDocumentCommand{\rhsangularmomentumprincipleupdate}{ s }{%
98   \IfBooleanTF{#1}%
99     {\vec*{L}}%
100    {\vec{L}}%
101  _{A\symup{,sys,initial}}+%
102  \IfBooleanTF{#1}%
103    {\vec*{\tau}}%
104    {\vec{\tau}}%
105  _{A\symup{,sys,net}}\,\Delta t%
106 }%
107 \NewDocumentCommand{\angularmomentumprinciple}{ s }{%
108  \IfBooleanTF{#1}%
109    {\lhsangularmomentumprinciple* = \rhsangularmomentumprinciple*}%
110    {\lhsangularmomentumprinciple = \rhsangularmomentumprinciple}%
```

```
111 }%
112 \NewDocumentCommand{\angularmomentumprincipleupdate}{ s }{%
113   \IfBooleanTF{#1}%
114     {\lhsangularmomentumprincipleupdate* = \rhsangularmomentumprincipleupdate*}%
115     {\lhsangularmomentumprincipleupdate = \rhsangularmomentumprincipleupdate}%
116 }%
117 \NewDocumentCommand{\energyof}{ m o }{%
118   E_{#1\IfValueT{#2}{,#2}}%
119 }%
120 \NewDocumentCommand{\systemenergy}{ o }{%
121   E_{\symup{sys}\IfValueT{#1}{,#1}}%
122 }%
123 \NewDocumentCommand{\particleenergy}{ o }{%
124   E_{\symup{particle}\IfValueT{#1}{,#1}}%
125 }%
126 \NewDocumentCommand{\restenergy}{ o }{%
127   E_{\symup{rest}\IfValueT{#1}{,#1}}%
128 }%
129 \NewDocumentCommand{\internalenergy}{ o }{%
130   E_{\symup{internal}\IfValueT{#1}{,#1}}%
131 }%
132 \NewDocumentCommand{\chemicalenergy}{ o }{%
133   E_{\symup{chem}\IfValueT{#1}{,#1}}%
134 }%
135 \NewDocumentCommand{\thermalenergy}{ o }{%
136   E_{\symup{therm}\IfValueT{#1}{,#1}}%
137 }%
138 \NewDocumentCommand{\photonenergy}{ o }{%
139   E_{\symup{photon}\IfValueT{#1}{,#1}}%
140 }%
141 \NewDocumentCommand{\translationalkineticenergy}{ s d[] }{%
142 % d[] must be used because of the way consecutive optional
143 %  arguments are handled. See xparse docs for details.
144 %  See https://tex.stackexchange.com/a/569011/218142
145   \IfBooleanTF{#1}%
146   {E_\bgroup \symup{K}}%
147   {K_\bgroup\symup{trans}}%
148       \IfValueT{#2}{,#2}%
149     \egroup%
150 }%
151 \NewDocumentCommand{\rotationalkineticenergy}{ s d[] }{%
152 % d[] must be used because of the way consecutive optional
153 %  arguments are handled. See xparse docs for details.
154 %  See https://tex.stackexchange.com/a/569011/218142
155   \IfBooleanTF{#1}%
156   {E_\bgroup}%
157   {K_\bgroup}%
158       \symup{rot}\IfValueT{#2}{,#2}%
159     \egroup%
160 }%
161 \NewDocumentCommand{\vibrationalkineticenergy}{ s d[] }{%
162 % d[] must be used because of the way consecutive optional
163 %  arguments are handled. See xparse docs for details.
164 %  See https://tex.stackexchange.com/a/569011/218142
165   \IfBooleanTF{#1}%
166   {E_\bgroup}%
167   {K_\bgroup}%
168       \symup{vib}\IfValueT{#2}{,#2}%
169     \egroup%
```

```
170 }%
171 \NewDocumentCommand{\gravitationalpotentialenergy}{ o }{%
172   U_{\symup{g}\IfValueT{#1}{,#1}}%
173 }%
174 \NewDocumentCommand{\electricpotentialenergy}{ o }{%
175   U_{\symup{e}\IfValueT{#1}{,#1}}%
176 }%
177 \NewDocumentCommand{\springpotentialenergy}{ o }{%
178   U_{\symup{s}\IfValueT{#1}{,#1}}%
179 }%
```

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