The mandi Bundle

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mandi version v3.2.0 dated 2023-08-01
mandistudent version v3.2.0 dated 2023-08-01
mandiexp version v3.2.0 dated 2023-08-01

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Acknowledgements

To all of the students who have learned LaTeX 2_ε 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 2_ε developers who inhabit the TeX StackExchange site. Entering a new culture is daunting for anyone, especially for newcomers; the LaTeX 2_ε development culture is no exception. We all share a passion for creating beautiful documents and I learned much over the summers of 2020 and 2021 that improved my ability to do just that. There are too many of you to list individually, and I would surely accidentally omit some were I to try. Collectively, I thank you all for your patience and advice.

Change History

List of Web VPython Programs

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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. 52 provides other typesetting capability appropriate for written problem solutions. Finally, package `mandiexp`→ P. 83 provides commands for typesetting expressions from *Matter & Interactions*[2]

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

2 Getting Help

If you have a question about mandi, first please read this documentation to make sure your question is not addressed here. Then if you wish, email me. As a user, you deserve courteous and timely help if you need it. You will never get a response from me saying that because this software is free you are not entitled to help using it. It is sad that some developers take that attitude. Using free software does not absolve the developer of helping users unless the license specifically says so.

3 Code Availability

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

4 Compatibility with Other Packages and Classes

When using BEAMER, certain commands in the mandistudent package are not defined. Because BEAMER uses the enumitem package, the `physicsproblem`→ P. 56 and `physicsproblem*`→ P. 56 environments are not defined. The `\hilite`→ P. 58 command is also not defined because it does not work and I do not currently know why.

[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.

5 Student/Instructor Quick Guide

Use `\vec`→ P. 52 to typeset the symbol for a vector. Use `\magnitude`→ P. 55 to typeset the symbol for a vector's magnitude. Use `\dirvec`→ P. 52 to typeset the symbol for a vector's direction. Use `\changein`→ P. 53 to typeset the symbol for the change in a vector or scalar. Use `\zerovec`→ P. 53 to typeset the zero vector. Use `\timestento`→ P. 34 to typeset scientific notation.

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

$\boldsymbol{p}$ or $\vec{p}$
$\boldsymbol{p}_{\text{final}}$ or $\vec{p}_{\text{final}}$
$\|\boldsymbol{p}\|$ or $\|\boldsymbol{p}_{\text{final}}\|$
$\widehat{\boldsymbol{p}}$ or $\widehat{p}$
$\Delta\boldsymbol{p}$ or Δt
$\mathbf{0}$ or $\vec{0}$
6.02×10^{-19}

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

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

$7.071\,\mathrm{kg \cdot m/s}$
$\langle 3, -4, 5 \rangle\,\mathrm{kg \cdot m/s}$
$\langle 3, -4, 5 \rangle\,\mathrm{kg \cdot m/s}$

Use a `physical constant's`→ P. 23 name to typeset its numerical value and units. Append `mathsymbol` to the constant's name to get its mathematical symbol. For example, if you want to typeset the vacuum permittivity, use `\vacuumpermittivity`→ P. 30 and its variant.

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

$\epsilon_{\mathrm{o}} = 9 \times 10^{-12}\,\mathrm{C^2/N \cdot m^2}$

Use `\mivector`→ P. 34 to typeset symbolic vectors with components. Use the alias `\direction`→ 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
```

$\langle \underline{\quad}, \underline{\quad}, \underline{\quad} \rangle$ or $\langle p_x, p_y, p_z \rangle$
$\frac{1}{\sqrt{3}}, \frac{1}{\sqrt{3}}, \frac{1}{\sqrt{3}}$ or

Use `physicsproblem`→ P. 56 and `parts`→ P. 56 and `\problempart`→ P. 56 for problems. For step-by-step mathematical solutions use `physicssolution`→ P. 57. Use `webvpythonblock`→ P. 62 to typeset `Web VPython` programs. Use `\vpythonfile`→ P. 68 to typeset VPython program files.

6 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 v3.2.0 dated 2023-08-01 and is a stable build.

6.1 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**.

6.2 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}
```

6.3 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.

6.4 Physical Quantities

6.4.1 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.

N 2021-02-24

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

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.

```
\( \momentum{5} \)                          \\
\( \momentumvalue{5} \)                     \\
\( \momentumbaseunits{5} \)                 \\
\( \momentumderivedunits{5} \)              \\
\( \momentumalternateunits{5} \)            \\
\( \momentumvector{2,3,4} \)                \\
\( \vectormomentum{2,3,4} \)                \\
\( \momentum{\mivector{2,3,4}} \)           \\
\( \momentumonlybaseunits \)                \\
\( \momentumonlyderivedunits \)             \\
\( \momentumonlyalternateunits \)           \\
\( \momentumvectorvalue{2,3,4} \)           \\
\( \vectormomentumvalue{2,3,4} \)           \\
\( \momentumvectorbaseunits{2,3,4} \)       \\
\( \vectormomentumbaseunits{2,3,4} \)       \\
\( \momentumvectorderivedunits{2,3,4} \)    \\
\( \vectormomentumderivedunits{2,3,4} \)    \\
\( \momentumvectoralternateunits{2,3,4} \) \\
\( \vectormomentumalternateunits{2,3,4} \) \\
\( \momentumvectoronlybaseunits \)          \\
\( \vectormomentumonlybaseunits \)          \\
\( \momentumvectoronlyderivedunits \)       \\
\( \vectormomentumonlyderivedunits \)       \\
\( \momentumvectoronlyalternateunits \)     \\
\( \vectormomentumonlyalternateunits \)
```

$5\,\mathrm{kg\cdot m/s}$
5
$5\,\mathrm{kg\cdot m\cdot s^{-1}}$
$5\,\mathrm{kg\cdot m/s}$
$5\,\mathrm{kg\cdot m/s}$
$\langle 2,3,4\rangle\,\mathrm{kg\cdot m/s}$
$\langle 2,3,4\rangle\,\mathrm{kg\cdot m/s}$
$\langle 2,3,4\rangle\,\mathrm{kg\cdot m/s}$
$\mathrm{kg\cdot m\cdot s^{-1}}$
$\mathrm{kg\cdot m/s}$
$\mathrm{kg\cdot m/s}$
$\langle 2,3,4\rangle$
$\langle 2,3,4\rangle$
$\langle 2,3,4\rangle\,\mathrm{kg\cdot m\cdot s^{-1}}$
$\langle 2,3,4\rangle\,\mathrm{kg\cdot m\cdot s^{-1}}$
$\langle 2,3,4\rangle\,\mathrm{kg\cdot m/s}$
$\langle 2,3,4\rangle\,\mathrm{kg\cdot m/s}$
$\langle 2,3,4\rangle\,\mathrm{kg\cdot m/s}$
$\langle 2,3,4\rangle\,\mathrm{kg\cdot m/s}$
$\mathrm{kg\cdot m\cdot s^{-1}}$
$\mathrm{kg\cdot m\cdot s^{-1}}$
$\mathrm{kg\cdot m/s}$
$\mathrm{kg\cdot m/s}$
$\mathrm{kg\cdot m/s}$
$\mathrm{kg\cdot m/s}$

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.

6.4.2 Checking Physical Quantities

U 2022-01-27 `\CheckQuantity{⟨name⟩}`

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

6.4.3 Predefined Physical Quantities

Every other defined physical quantity can be treated similarly. Just replace `momentum` with the quantity's name. Obviously, the variants that begin with `\vector` will not be defined for scalar quantities. Here are all the physical quantities, with all their units, defined in `mandi`. Remember that units are not present with symbolic (algebraic) quantities, so do not use the `\vector` variants of these commands for symbolic components. Use `\mivector` → P. 34 instead.

`\acceleration{⟨magnitude⟩}`
N 2021-02-24 `\accelerationvector{⟨c_1, ..., c_n⟩}`
`\vectoracceleration{⟨c_1, ..., c_n⟩}`

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

`\amount{⟨magnitude⟩}`

command	`\amount`	
base	**derived**	**alternate**
mol	mol	mol

`\angularacceleration{⟨magnitude⟩}`
N 2021-02-24 `\angularaccelerationvector{⟨c_1, ..., c_n⟩}`
`\vectorangularacceleration{⟨c_1, ..., c_n⟩}`

command	`\angularacceleration`	
base	**derived**	**alternate**
$\mathrm{rad \cdot s^{-2}}$	$\mathrm{rad/s^2}$	$\mathrm{rad/s^2}$

`\angularfrequency{⟨magnitude⟩}`

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

`\angularimpulse{⟨magnitude⟩}`
N 2021-02-24 `\angularimpulsevector{⟨c_1, ..., c_n⟩}`
`\vectorangularimpulse{⟨c_1, ..., c_n⟩}`

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

N 2021-02-24

\angularmomentum{⟨*magnitude*⟩}
\angularmomentumvector{⟨$c_1, \dots, c_n$⟩}
\vectorangularmomentum{⟨$c_1, \dots, c_n$⟩}

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

N 2021-02-24

\angularvelocity{⟨*magnitude*⟩}
\angularvelocityvector{⟨$c_1, \dots, c_n$⟩}
\vectorangularvelocity{⟨$c_1, \dots, c_n$⟩}

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

\area{⟨*magnitude*⟩}

command	`\area`	
base	**derived**	**alternate**
m^2	m^2	m^2

\areachargedensity{⟨*magnitude*⟩}

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

\areamassdensity{⟨*magnitude*⟩}

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

\capacitance{⟨*magnitude*⟩}

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

\charge{⟨*magnitude*⟩}

command	`\charge`	
base	**derived**	**alternate**
$\mathrm{A} \cdot \mathrm{s}$	C	C

N 2021-02-24

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

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

\conductance{⟨*magnitude*⟩}

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

\conductivity{⟨*magnitude*⟩}

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

\conventionalcurrent{⟨*magnitude*⟩}

command	`\conventionalcurrent`	
base	**derived**	**alternate**
A	C/s	A

\current{⟨*magnitude*⟩}

command	`\current`	
base	**derived**	**alternate**
A	A	A

N 2021-02-24

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

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

\dielectricconstant{⟨*magnitude*⟩}

command	`\dielectricconstant`	
base	**derived**	**alternate**

N 2021-02-24

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

command	`\direction`	
base	**derived**	**alternate**

N 2021-02-24

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

command	`\displacement`	
base	**derived**	**alternate**
m	m	m

`\duration{⟨magnitude⟩}`

command	`\duration`	
base	**derived**	**alternate**
s	s	s

N 2021-02-24

`\electricdipolemoment{⟨magnitude⟩}`
`\electricdipolemomentvector{⟨c_1, ..., c_n⟩}`
`\vectorelectricdipolemoment{⟨c_1, ..., c_n⟩}`

command	`\electricdipolemoment`	
base	**derived**	**alternate**
$\mathrm{A \cdot s \cdot m}$	$\mathrm{C \cdot m}$	$\mathrm{C \cdot m}$

N 2021-02-24

`\electricfield{⟨magnitude⟩}`
`\electricfieldvector{⟨c_1, ..., c_n⟩}`
`\vectorelectricfield{⟨c_1, ..., c_n⟩}`

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

`\electricflux{⟨magnitude⟩}`

command	`\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⟩}`

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

N 2021-05-01 **\electricpotentialdifference**{⟨*magnitude*⟩}

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

\electroncurrent{⟨*magnitude*⟩}

command	\electroncurrent	
base	**derived**	**alternate**
s^{-1}	e/s	e/s

\emf{⟨*magnitude*⟩}

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

\energy{⟨*magnitude*⟩}

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

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

command	\energyinev	
base	**derived**	**alternate**
eV	eV	eV

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

command	\energyinkev	
base	**derived**	**alternate**
keV	keV	keV

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

command	\energyinmev	
base	**derived**	**alternate**
MeV	MeV	MeV

\energydensity{⟨*magnitude*⟩}

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

N 2021-02-24

\energyflux{⟨*magnitude*⟩}
\energyfluxvector{⟨$c_1, \dots, c_n$⟩}
\vectorenergyflux{⟨$c_1, \dots, c_n$⟩}

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

\entropy{⟨*magnitude*⟩}

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

N 2021-02-24

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

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

\frequency{⟨*magnitude*⟩}

command	`\frequency`	
base	**derived**	**alternate**
$\mathrm{s^{-1}}$	Hz	Hz

N 2021-02-24

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

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

\gravitationalpotential{⟨*magnitude*⟩}

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

N 2021-05-01

\gravitationalpotentialdifference{⟨*magnitude*⟩}

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

N 2021-02-24

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

command	\impulse	
base	**derived**	**alternate**
$kg \cdot m \cdot s^{-1}$	$N \cdot s$	$N \cdot s$

\indexofrefraction{⟨*magnitude*⟩}

command	\indexofrefraction	
base	**derived**	**alternate**

\inductance{⟨*magnitude*⟩}

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

\linearchargedensity{⟨*magnitude*⟩}

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

\linearmassdensity{⟨*magnitude*⟩}

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

N 2022-01-27

\lorentzfactor{⟨*magnitude*⟩}

command	\lorentzfactor	
base	**derived**	**alternate**

U 2021-05-02

\luminousintensity{⟨*magnitude*⟩}

command	\luminousintensity	
base	**derived**	**alternate**
cd	cd	cd

\magneticcharge{⟨*magnitude*⟩}

command	\magneticcharge	
base	**derived**	**alternate**
$A \cdot m$	$A \cdot m$	$A \cdot m$

\magneticdipolemoment{⟨*magnitude*⟩}
N 2021-02-24 **\magneticdipolemomentvector**{⟨$c_1, \ldots, c_n$⟩}
\vectormagneticdipolemoment{⟨$c_1, \ldots, c_n$⟩}

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

\magneticfield{⟨*magnitude*⟩}
N 2021-02-24 **\magneticfieldvector**{⟨$c_1, \ldots, c_n$⟩}
\vectormagneticfield{⟨$c_1, \ldots, c_n$⟩}

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

\magneticflux{⟨*magnitude*⟩}

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

\mass{⟨*magnitude*⟩}

command	\mass	
base	**derived**	**alternate**
kg	kg	kg

\mobility{⟨*magnitude*⟩}

command	\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*⟩}

command	\momentofinertia	
base	**derived**	**alternate**
$kg \cdot m^2$	$J \cdot s^2$	$kg \cdot m^2$

N 2021-02-24

`\momentum{⟨magnitude⟩}`
`\momentumvector{`$\langle c_1, \ldots, c_n \rangle$`}`
`\vectormomentum{`$\langle c_1, \ldots, c_n \rangle$`}`

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

N 2021-02-24

`\momentumflux{⟨magnitude⟩}`
`\momentumfluxvector{`$\langle c_1, \ldots, c_n \rangle$`}`
`\vectormomentumflux{`$\langle c_1, \ldots, c_n \rangle$`}`

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

`\numberdensity{⟨magnitude⟩}`

command	\numberdensity	
base	**derived**	**alternate**
m^{-3}	$/m^3$	$/m^3$

`\permeability{⟨magnitude⟩}`

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

`\permittivity{⟨magnitude⟩}`

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

`\planeangle{⟨magnitude⟩}`

command	\planeangle	
base	**derived**	**alternate**
$m \cdot m^{-1}$	rad	rad

`\polarizability{⟨magnitude⟩}`

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

`\power{⟨magnitude⟩}`

command	`\power`	
base	**derived**	**alternate**
$kg \cdot m^2 \cdot s^{-3}$	W	J/s

N 2021-02-24

`\poynting{⟨magnitude⟩}`
`\poyntingvector{⟨c_1, …, c_n⟩}`
`\vectorpoynting{⟨c_1, …, c_n⟩}`

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

`\pressure{⟨magnitude⟩}`

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

`\relativepermeability{⟨magnitude⟩}`

command	`\relativepermeability`	
base	**derived**	**alternate**

`\relativepermittivity{⟨magnitude⟩}`

command	`\relativepermittivity`	
base	**derived**	**alternate**

`\resistance{⟨magnitude⟩}`

command	`\resistance`	
base	**derived**	**alternate**
$kg \cdot m^2 \cdot A^{-2} \cdot s^{-3}$	Ω	Ω

`\resistivity{⟨magnitude⟩}`

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

`\solidangle{⟨magnitude⟩}`

command	`\solidangle`	
base	**derived**	**alternate**
$m^2 \cdot m^{-2}$	sr	sr

\specificheatcapacity{⟨*magnitude*⟩}

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

\springstiffness{⟨*magnitude*⟩}

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

\springstretch{⟨*magnitude*⟩}

command	\springstretch	
base	**derived**	**alternate**
m	m	m

\stress{⟨*magnitude*⟩}

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

\strain{⟨*magnitude*⟩}

command	\strain	
base	**derived**	**alternate**

\temperature{⟨*magnitude*⟩}

command	\temperature	
base	**derived**	**alternate**
K	K	K

\torque{⟨*magnitude*⟩}
N 2021-02-24 **\torquevector**{⟨$c_1, \ldots, c_n$⟩}
\vectortorque{⟨$c_1, \ldots, c_n$⟩}

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

\velocity{⟨*magnitude*⟩}
N 2021-02-24 **\velocityvector**{⟨$c_1, \ldots, c_n$⟩}
\vectorvelocity{⟨$c_1, \ldots, c_n$⟩}

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

`\velocityc`{⟨*magnitude*⟩}
N 2021-02-24 `\velocitycvector`{⟨$c_1, \ldots, c_n$⟩}
`\vectorvelocityc`{⟨$c_1, \ldots, c_n$⟩}

command	`\velocityc`	
base	**derived**	**alternate**
c	c	c

`\volume`{⟨*magnitude*⟩}

command	`\volume`	
base	**derived**	**alternate**
$\mathrm{m^3}$	$\mathrm{m^3}$	$\mathrm{m^3}$

`\volumechargedensity`{⟨*magnitude*⟩}

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

`\volumemassdensity`{⟨*magnitude*⟩}

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

`\wavelength`{⟨*magnitude*⟩}

command	`\wavelength`	
base	**derived**	**alternate**
m	m	m

`\wavenumber`{⟨*magnitude*⟩}
N 2021-02-24 `\wavenumbervector`{⟨$c_1, \ldots, c_n$⟩}
`\vectorwavenumber`{⟨$c_1, \ldots, c_n$⟩}

command	`\wavenumber`	
base	**derived**	**alternate**
$\mathrm{m^{-1}}$	/m	/m

`\work`{⟨*magnitude*⟩}

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

`\youngsmodulus{⟨magnitude⟩}`

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

6.4.4 Defining and Redefining Physical Quantities

N 2021-02-16 `\NewScalarQuantity{⟨name⟩}{⟨base units⟩}[⟨derived units⟩][⟨alternate units⟩]`
N 2021-02-21 `\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.

N 2021-02-16 `\NewVectorQuantity{⟨name⟩}{⟨base units⟩}[⟨derived units⟩][⟨alternate units⟩]`
N 2021-02-21 `\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.

6.4.5 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` → P. 9 or `physical constant` → P. 23 is defined, a global modal command (switch), a command that sets units for a single instance, and an environment that sets units for its duration. All of these methods work for both physical quantities and physical constants.

U 2021-02-26 `\alwaysusebaseunits`
U 2021-02-26 `\alwaysusederivedunits`
U 2021-02-26 `\alwaysusealternateunits`

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

U 2021-02-26 `\hereusebaseunits{⟨content⟩}`
U 2021-02-26 `\hereusederivedunits{⟨content⟩}`
U 2021-02-26 `\hereusealternateunits{⟨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.

```
\( \hereusebaseunits{\momentum{5}} \)      \\
\( \hereusederivedunits{\momentum{5}} \)   \\
\( \hereusealternateunits{\momentum{5}} \) \\
\( \hereusebaseunits{\oofpez} \)           \\
\( \hereusederivedunits{\oofpez} \)        \\
\( \hereusealternateunits{\oofpez} \)
```

$5\,\mathrm{kg\cdot m\cdot s^{-1}}$
$5\,\mathrm{kg\cdot m/s}$
$5\,\mathrm{kg\cdot m/s}$
$9\times10^{9}\,\mathrm{kg\cdot m^{3}\cdot A^{-2}\cdot s^{-4}}$
$9\times10^{9}\,\mathrm{m/F}$
$9\times10^{9}\,\mathrm{N\cdot m^{2}/C^{2}}$

U 2021-02-26 `\begin{usebaseunits}` (use base units)
⟨*environment content*⟩
`\end{usebaseunits}`

U 2021-02-26 `\begin{usederivedunits}` (use derived units)
⟨*environment content*⟩
`\end{usederivedunits}`

U 2021-02-26 `\begin{usealternateunits}` (use alternate units)
⟨*environment content*⟩
`\end{usealternateunits}`

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

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

$5\,\mathrm{kg\cdot m/s}$
$9\times10^{9}\,\mathrm{N\cdot m^{2}/C^{2}}$
$5\,\mathrm{kg\cdot m\cdot s^{-1}}$
$9\times10^{9}\,\mathrm{kg\cdot m^{3}\cdot A^{-2}\cdot s^{-4}}$
$5\,\mathrm{kg\cdot m/s}$
$9\times10^{9}\,\mathrm{m/F}$
$5\,\mathrm{kg\cdot m/s}$
$9\times10^{9}\,\mathrm{N\cdot m^{2}/C^{2}}$

6.5 Physical Constants

6.5.1 Typesetting Physical Constants

Take the quantity $\frac{1}{4\pi\epsilon_o}$, 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.

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

$9 \times 10^9\,\mathrm{N \cdot m^2/C^2}$
9×10^9
8.9875517923×10^9
$\frac{1}{4\pi\epsilon_o}$
$9 \times 10^9\,\mathrm{kg \cdot m^3 \cdot A^{-2} \cdot s^{-4}}$
$9 \times 10^9\,\mathrm{m/F}$
$9 \times 10^9\,\mathrm{N \cdot m^2/C^2}$
$\mathrm{kg \cdot m^3 \cdot A^{-2} \cdot s^{-4}}$
$\mathrm{m/F}$
$\mathrm{N \cdot m^2/C^2}$

6.5.2 Checking Physical Constants

U 2022-01-27 `\CheckConstant{⟨name⟩}`

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

6.5.3 Predefined Physical Constants

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

`\avogadro` (exact)

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

N 2021-02-02 `\biotsavartconstant`

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

`\bohrradius`

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

\boltzmann (exact)

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

N 2021-02-02

\coulombconstant

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

\earthmass

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

\earthmoondistance

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

\earthradius

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

\earthsundistance

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

\electroncharge

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

\electronCharge

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

\electronmass

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

\elementarycharge (exact)

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

\finestructure

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

\hydrogenmass

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

\moonearthdistance

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

\moonmass

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

\moonradius

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

\mzofp

command	\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

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

\oofpez

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

`\oofpezcs`

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

`\planck` (exact)

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

`\planckbar`

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

`\planckc`

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

`\protoncharge`

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

`\protonCharge`

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

\protonmass

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

\rydberg

command	\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)

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

\stefanboltzmann

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

\sunearthdistance

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

\sunradius

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

`\surfacegravfield`

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

`\universalgrav`

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

`\vacuumpermeability`

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

`\vacuumpermittivity`

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

6.5.4 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.

6.5.5 Changing Precision

Changing units → P. 22 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.

```
\( \hereuseapproximateconstants{\oofpez} \) \\
\( \hereusepreciseconstants{\oofpez} \)
```

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

N 2021-02-16 `\begin{useapproximateconstants}` (use approximate constants)
  ⟨*environment content*⟩
`\end{useapproximateconstants}`
N 2021-02-16 `\begin{usepreciseconstants}` (use precise constants)
  ⟨*environment content*⟩
`\end{usepreciseconstants}`

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

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

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

6.6 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`
U 2023-08-01 `\units{⟨magnitude⟩}{⟨unit⟩}`
`\emptyunit`
`\ampere`
`\atomicmassunit`
`\candela`

	\coulomb	
	\degree	
	\electronvolt	(not SI but common in introductory physics)
N 2021-04-15	\ev	(alias)
	\farad	
	\henry	
	\hertz	
	\joule	
	\kelvin	
N 2021-04-15	\kev	(alias)
N 2021-04-15	\kiloelectronvolt	(not SI but common in introductory physics)
	\kilogram	
	\lightspeed	(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)

```
\( \per \)                          \\
\( \usk \)                          \\
\( \units{3}{\meter\per\second} \)  \\
\( \emptyunit \)                    \\
\( \ampere \)                       \\
\( \atomicmassunit \)               \\
\( \candela \)                      \\
\( \coulomb \)                      \\
\( \degree \)                       \\
\( \electronvolt \)                 \\
\( \farad \)                        \\
\( \henry \)                        \\
\( \hertz \)                        \\
\( \joule \)                        \\
\( \kelvin \)                       \\
\( \kev \)                          \\
\( \kilogram \)                     \\
\( \lightspeed \)                   \\
\( \meter \)                        \\
\( \metre \)                        \\
\( \mev \)                          \\
\( \mole \)                         \\
\( \newton \)                       \\
\( \ohm \)                          \\
\( \pascal \)                       \\
\( \radian \)                       \\
\( \second \)                       \\
\( \siemens \)                      \\
\( \steradian \)                    \\
\( \tesla \)                        \\
\( \volt \)                         \\
\( \watt \)                         \\
\( \weber \)                        \\
\( \emptyunit\tothetwo \)           \\
\( \emptyunit\tothethree \)         \\
\( \emptyunit\tothefour \)          \\
\( \emptyunit\inverse \)            \\
\( \emptyunit\totheinversetwo \)    \\
\( \emptyunit\totheinversethree \)  \\
\( \emptyunit\totheinversefour \)
```

/
·
$3\,\mathrm{m/s}$
$\square$
A
u
cd
C
$^\circ$
eV
F
H
Hz
J
K
keV
kg
c
m
m
MeV
mol
N
Ω
Pa
rad
s
S
sr
T
V
W
Wb
$\square^{2}$
$\square^{3}$
$\square^{4}$
$\square^{-1}$
$\square^{-2}$
$\square^{-3}$
$\square^{-4}$

N 2022-01-27 **\hbar**

A better glyph for Planck's constant over 2π.

```
\( \hbar \)
```

$\hbar$

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

Commands for powers of ten and scientific notation.

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

10^{-4}
3×10^{8}
3×10^{8}

U 2022-01-27 `\mivector[⟨delimiter⟩]{⟨c_1, ..., c_n⟩}[⟨units⟩]`

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

```
\( \mivector{p_0,p_1,p_2,p_3} \)                                   \\
\( \mivector{\gamma mc,\gamma mv_x,\gamma mv_y,\gamma mv_z} \) \\
\( \mivector{\frac{Q_1Q_2}{x^2},0,0} \)                            \\
\( \mivector{-1,0,0} \)                                            \\
\( \mivector{-1,0,0}[\velocityonlyderivedunits] \)                 \\
\( \mivector{-1,0,0}[\meter\per\second] \)                         \\
\( \velocity{\mivector{-1,0,0}} \)
```

$\langle p_0, p_1, p_2, p_3 \rangle$
$\langle \gamma mc, \gamma mv_x, \gamma mv_y, \gamma mv_z \rangle$
$\left\langle \frac{Q_1Q_2}{x^2}, 0, 0 \right\rangle$
$\langle -1, 0, 0 \rangle$
$\langle -1, 0, 0 \rangle$ m/s
$\langle -1, 0, 0 \rangle$ m/s
$\langle -1, 0, 0 \rangle$ m/s

6.7 mandi Source Code

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

```
\def\mandi@version{3.2.0}
\def\mandi@date{2023-08-01}
\NeedsTeXFormat{LaTeX2e}[2020-02-02]
\DeclareRelease{v3.2.0}{2023-08-01}{mandi.sty}
\DeclareCurrentRelease{v\mandi@version}{\mandi@date}
\ProvidesPackage{mandi}
  [\mandi@date\space v\mandi@version\space Macros for physical quantities]
```

Define a convenient package version command.

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

Load third party packages, documenting why each one is needed.
We need pgfopts for a key-value interface.

```
\RequirePackage{pgfopts}
```

We need array for \chkquantity and \chkconstant.

```
\RequirePackage{array}
```

We need iftex so we can require LuaLaTeX.

```
\RequirePackage{iftex}
```

We need mathtools for intelligent delimiters.

```
\RequirePackage{mathtools}
```

We need unicode-math for Unicode support and changing fonts.

```
\RequirePackage{unicode-math}
```

Suppress some annoying warnings.

```
\unimathsetup{warnings-off={mathtools-colon,mathtools-overbracket}}
```

Load xparse if necessary.

```
\IfFormatAtLeastTF{2020-10-01}
  {}%
  {\RequirePackage{xparse}}%
```

We require the LuaLaTeX engine.

```
\RequireLuaTeX
```

Parts of the unit engine have been rewritten with xparse for both clarity and power. Note that xparse is now part of the LaTeX 2ε kernel. Other parts have been rewritten in expl with a look to the future.

Define some generic internal selectors.

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

Define some specific internal selectors. The first two are really just workalikes for \@firstoftwo and \@secondoftwo. The third, fourth, and fifth are \@firstofthree, \@secondofthree, and \@thirdofthree and apparently do not yet exist.

```
\newcommand*{\mandi@selectapproximate}[2]{#1}
\newcommand*{\mandi@selectprecise}[2]{#2}
\newcommand*{\mandi@selectbaseunits}[3]{#1}
\newcommand*{\mandi@selectderivedunits}[3]{#2}
\newcommand*{\mandi@selectalternateunits}[3]{#3}
```

Document level global switches.

```
\NewDocumentCommand{\alwaysusebaseunits}{}
  {\renewcommand*{\mandi@selectunits}{\mandi@selectbaseunits}}%
\NewDocumentCommand{\alwaysusederivedunits}{}
  {\renewcommand*{\mandi@selectunits}{\mandi@selectderivedunits}}%
\NewDocumentCommand{\alwaysusealternateunits}{}
  {\renewcommand*{\mandi@selectunits}{\mandi@selectalternateunits}}%
\NewDocumentCommand{\alwaysuseapproximateconstants}{}
  {\renewcommand*{\mandi@selectprecision}{\mandi@selectapproximate}}%
\NewDocumentCommand{\alwaysusepreciseconstants}{}
  {\renewcommand*{\mandi@selectprecision}{\mandi@selectprecise}}%
```

Document level localized variants.

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

Document level environments.

```
\NewDocumentEnvironment{usebaseunits}{}{\alwaysusebaseunits}{}%
\NewDocumentEnvironment{usederivedunits}{}{\alwaysusederivedunits}{}%
\NewDocumentEnvironment{usealternateunits}{}{\alwaysusealternateunits}{}%
\NewDocumentEnvironment{useapproximateconstants}{}{\alwaysuseapproximateconstants}{}%
\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.

```
\newif\ifusingpreciseconstants
\pgfkeys{%
  /mandi/options/.cd,
  initial@setup/.style={%
    /mandi/options/buffered@units/.initial=alternate,%
  },%
  initial@setup,%
  preciseconstants/.is if=usingpreciseconstants,%
  units/.is choice,%
  units/.default=derived,%
  units/alternate/.style={/mandi/options/buffered@units=alternate},%
  units/base/.style={/mandi/options/buffered@units=base},%
  units/derived/.style={/mandi/options/buffered@units=derived},%
  .unknown/.code={%
    \typeout{}%
    \typeout{mandi: You used unknown option '\pgfkeyscurrentname'.}%
  },%
}%
```

Process the options.

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

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

```
\typeout{}%
\typeout{mandi: You are using mandi \mandiversion.}%
\typeout{mandi: This package requires LuaLaTeX.}%
\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.

```
\newcommand*{\mandi@do@setup}{%
  \csname alwaysuse\pgfkeysvalueof{/mandi/options/buffered@units}units\endcsname%
  \typeout{mandi: You will get \pgfkeysvalueof{/mandi/options/buffered@units}\space units.}%
  \ifusingpreciseconstants
    \alwaysusepreciseconstants
    \typeout{mandi: You will get precise constants.}%
  \else
    \alwaysuseapproximateconstants
    \typeout{mandi: You will get approximate constants.}%
  \fi
  \typeout{}%
}%
\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.

```
\NewDocumentCommand{\mandisetup}{ m }%
  {%
    \IfValueT{#1}%
      {%
        \pgfqkeys{/mandi/options}{#1}
        \typeout{}%
        \typeout{mandi: mandisetup options...}
        \mandi@do@setup
      }%
  }%
```

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 SIunits package. We make use of `\symup{...}` from the unicode-math package.

```
\NewDocumentCommand{\per}{}{/}
\NewDocumentCommand{\usk}{}{\cdot}
\NewDocumentCommand{\units}{ m m }%
{%
  \IfValueTF{#2}
  {%
    {#1}{\,#2}
  }%
  {%
    {#1}{}
  }%
}%
\NewDocumentCommand{\ampere}{}{\symup{A}}
\NewDocumentCommand{\atomicmassunit}{}{\symup{u}}
\NewDocumentCommand{\candela}{}{\symup{cd}}
\NewDocumentCommand{\coulomb}{}{\symup{C}}
\NewDocumentCommand{\degree}{}{^{\circ}}
\NewDocumentCommand{\electronvolt}{}{\symup{eV}}
\NewDocumentCommand{\ev}{}{\electronvolt}
\NewDocumentCommand{\farad}{}{\symup{F}}
\NewDocumentCommand{\henry}{}{\symup{H}}
\NewDocumentCommand{\hertz}{}{\symup{Hz}}
\NewDocumentCommand{\joule}{}{\symup{J}}
\NewDocumentCommand{\kelvin}{}{\symup{K}}
\NewDocumentCommand{\kev}{}{\kiloelectronvolt}
\NewDocumentCommand{\kiloelectronvolt}{}{\symup{keV}}
\NewDocumentCommand{\kilogram}{}{\symup{kg}}
```

```
\NewDocumentCommand{\lightspeed}{}{\!\symup{c}}
\NewDocumentCommand{\megaelectronvolt}{}{\symup{MeV}}
\NewDocumentCommand{\meter}{}{\symup{m}}
\NewDocumentCommand{\metre}{}{\meter}
\NewDocumentCommand{\mev}{}{\megaelectronvolt}
\NewDocumentCommand{\mole}{}{\symup{mol}}
\NewDocumentCommand{\newton}{}{\symup{N}}
\NewDocumentCommand{\ohm}{}{\symup\Omega}
\NewDocumentCommand{\pascal}{}{\symup{Pa}}
\NewDocumentCommand{\radian}{}{\symup{rad}}
\NewDocumentCommand{\second}{}{\symup{s}}
\NewDocumentCommand{\siemens}{}{\symup{S}}
\NewDocumentCommand{\steradian}{}{\symup{sr}}
\NewDocumentCommand{\tesla}{}{\symup{T}}
\NewDocumentCommand{\volt}{}{\symup{V}}
\NewDocumentCommand{\watt}{}{\symup{W}}
\NewDocumentCommand{\weber}{}{\symup{Wb}}
\NewDocumentCommand{\tothetwo}{}{^{2}}
\NewDocumentCommand{\tothethree}{}{^{3}}
\NewDocumentCommand{\tothefour}{}{^{4}}
\NewDocumentCommand{\inverse}{}{^{-1}}
\NewDocumentCommand{\totheinversetwo}{}{^{-2}}
\NewDocumentCommand{\totheinversethree}{}{^{-3}}
\NewDocumentCommand{\totheinversefour}{}{^{-4}}
\NewDocumentCommand{\emptyunit}{}{\mdlgwhtsquare}
\NewDocumentCommand{\tento}{ m }{10^{#1}}
\NewDocumentCommand{\timestento}{ m }{\times\tento{#1}}
\NewDocumentCommand{\xtento}{ m }{\times\tento{#1}}
```

```
\ExplSyntaxOn
\cs_new:Npn \__mandi_newscalarquantity:nnnn #1#2#3#4
  {
    \cs_new:cpn {#1} ##1 {\units{##1}{\mandi@selectunits{#2}{#3}{#4}}}
    \cs_new:cpn {#1value} ##1 {##1}
    \cs_new:cpn {#1baseunits} ##1 {\units{##1}{\mandi@selectbaseunits{#2}{#3}{#4}}}
    \cs_new:cpn {#1derivedunits} ##1 {\units{##1}{\mandi@selectderivedunits{#2}{#3}{#4}}}
    \cs_new:cpn {#1alternateunits} ##1 {\units{##1}{\mandi@selectalternateunits{#2}{#3}{#4}}}
    \cs_new:cpn {#1onlybaseunits} {\mandi@selectbaseunits{#2}{#3}{#4}}
    \cs_new:cpn {#1onlyderivedunits} {\mandi@selectderivedunits{#2}{#3}{#4}}
    \cs_new:cpn {#1onlyalternateunits} {\mandi@selectalternateunits{#2}{#3}{#4}}
  }
\NewDocumentCommand{\NewScalarQuantity}{ m m O{#2} O{#2} }
  {
    \__mandi_newscalarquantity:nnnn { #1 }{ #2 }{ #3 }{ #4 }
  }
\ExplSyntaxOff
```

Redefining an existing scalar quantity.

```
\ExplSyntaxOn
\cs_new:Npn \__mandi_renewscalarquantity:nnnn #1#2#3#4
  {
    \cs_set:cpn {#1} ##1 {\units{##1}{\mandi@selectunits{#2}{#3}{#4}}}
    \cs_set:cpn {#1value} ##1 {##1}
    \cs_set:cpn {#1baseunits} ##1 {\units{##1}{\mandi@selectbaseunits{#2}{#3}{#4}}}
    \cs_set:cpn {#1derivedunits} ##1 {\units{##1}{\mandi@selectderivedunits{#2}{#3}{#4}}}
    \cs_set:cpn {#1alternateunits} ##1 {\units{##1}{\mandi@selectalternateunits{#2}{#3}{#4}}}
    \cs_set:cpn {#1onlybaseunits} {\mandi@selectbaseunits{#2}{#3}{#4}}
    \cs_set:cpn {#1onlyderivedunits} {\mandi@selectderivedunits{#2}{#3}{#4}}
    \cs_set:cpn {#1onlyalternateunits} {\mandi@selectalternateunits{#2}{#3}{#4}}
```

```
  }
\NewDocumentCommand{\RenewScalarQuantity}{ m m O{#2} O{#2} }
  {
    \__mandi_renewscalarquantity:nnnn { #1 }{ #2 }{ #3 }{ #4 }
  }
\ExplSyntaxOff
```

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

```
\ExplSyntaxOn
\cs_new:Npn \__mandi_newvectorquantity:nnnn #1#2#3#4
  {
    \__mandi_newscalarquantity:nnnn { #1 }{ #2 }{ #3 }{ #4 }
    \cs_new:cpn {vector#1} ##1 {\units{\mivector{##1}}{\mandi@selectunits{#2}{#3}{#4}}}
    \cs_new:cpn {#1vector} ##1 {\units{\mivector{##1}}{\mandi@selectunits{#2}{#3}{#4}}}
    \cs_new:cpn {vector#1value} ##1 {\mivector{##1}}
    \cs_new:cpn {#1vectorvalue} ##1 {\mivector{##1}}
    \cs_new:cpn {vector#1baseunits} ##1 {\units{\mivector{##1}}{\mandi@selectbaseunits{#2}{#3}{#4}}}
    \cs_new:cpn {#1vectorbaseunits} ##1 {\units{\mivector{##1}}{\mandi@selectbaseunits{#2}{#3}{#4}}}
    \cs_new:cpn {vector#1derivedunits} ##1 {\units{\mivector{##1}}{\mandi@selectderivedunits{#2}{#3}{#4}}}
    \cs_new:cpn {#1vectorderivedunits} ##1 {\units{\mivector{##1}}{\mandi@selectderivedunits{#2}{#3}{#4}}}
    \cs_new:cpn {vector#1alternateunits} ##1 {\units{\mivector{##1}}{\mandi@selectalternateunits{#2}{#3}{#4}}}
    \cs_new:cpn {#1vectoralternateunits} ##1 {\units{\mivector{##1}}{\mandi@selectalternateunits{#2}{#3}{#4}}}
    \cs_new:cpn {vector#1onlybaseunits} {\mandi@selectbaseunits{#2}{#3}{#4}}
    \cs_new:cpn {#1vectoronlybaseunits} {\mandi@selectbaseunits{#2}{#3}{#4}}
    \cs_new:cpn {vector#1onlyderivedunits} {\mandi@selectderivedunits{#2}{#3}{#4}}
    \cs_new:cpn {#1vectoronlyderivedunits} {\mandi@selectderivedunits{#2}{#3}{#4}}
    \cs_new:cpn {vector#1onlyalternateunits} {\mandi@selectalternateunits{#2}{#3}{#4}}
    \cs_new:cpn {#1vectoronlyalternateunits} {\mandi@selectalternateunits{#2}{#3}{#4}}
  }
\NewDocumentCommand{\NewVectorQuantity}{ m m O{#2} O{#2} }
  {
    \__mandi_newvectorquantity:nnnn { #1 }{ #2 }{ #3 }{ #4 }
  }
\ExplSyntaxOff
```

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

```
\ExplSyntaxOn
\cs_new:Npn \__mandi_renewvectorquantity:nnnn #1#2#3#4
  {
    \__mandi_renewscalarquantity:nnnn { #1 }{ #2 }{ #3 }{ #4 }
    \cs_set:cpn {vector#1} ##1 {\units{\mivector{##1}}{\mandi@selectunits{#2}{#3}{#4}}}
    \cs_set:cpn {#1vector} ##1 {\units{\mivector{##1}}{\mandi@selectunits{#2}{#3}{#4}}}
    \cs_set:cpn {vector#1value} ##1 {\mivector{##1}}
    \cs_set:cpn {#1vectorvalue} ##1 {\mivector{##1}}
    \cs_set:cpn {vector#1baseunits} ##1 {\units{\mivector{##1}}{\mandi@selectbaseunits{#2}{#3}{#4}}}
    \cs_set:cpn {#1vectorbaseunits} ##1 {\units{\mivector{##1}}{\mandi@selectbaseunits{#2}{#3}{#4}}}
    \cs_set:cpn {vector#1derivedunits} ##1 {\units{\mivector{##1}}{\mandi@selectderivedunits{#2}{#3}{#4}}}
    \cs_set:cpn {#1vectorderivedunits} ##1 {\units{\mivector{##1}}{\mandi@selectderivedunits{#2}{#3}{#4}}}
    \cs_set:cpn {vector#1alternateunits} ##1 {\units{\mivector{##1}}{\mandi@selectalternateunits{#2}{#3}{#4}}}
    \cs_set:cpn {#1vectoralternateunits} ##1 {\units{\mivector{##1}}{\mandi@selectalternateunits{#2}{#3}{#4}}}
    \cs_set:cpn {vector#1onlybaseunits} {\mandi@selectbaseunits{#2}{#3}{#4}}
    \cs_set:cpn {#1vectoronlybaseunits} {\mandi@selectbaseunits{#2}{#3}{#4}}
    \cs_set:cpn {vector#1onlyderivedunits} {\mandi@selectderivedunits{#2}{#3}{#4}}
    \cs_set:cpn {#1vectoronlyderivedunits} {\mandi@selectderivedunits{#2}{#3}{#4}}
    \cs_set:cpn {vector#1onlyalternateunits} {\mandi@selectalternateunits{#2}{#3}{#4}}
    \cs_set:cpn {#1vectoronlyalternateunits} {\mandi@selectalternateunits{#2}{#3}{#4}}
  }
\NewDocumentCommand{\RenewVectorQuantity}{ m m O{#2} O{#2} }
  {
```

```
    \__mandi_renewvectorquantity:nnnn { #1 }{ #2 }{ #3 }{ #4 }
  }
\ExplSyntaxOff
```

Defining a new physical constant.

```
\ExplSyntaxOn
\cs_new:Npn \__mandi_newphysicalconstant:nnnnnnn #1#2#3#4#5#6#7
  {
    \cs_new:cpn {#1} {\units{\mandi@selectprecision{#3}{#4}}{\mandi@selectunits{#5}{#6}{#7}}}
    \cs_new:cpn {#1mathsymbol} {#2}
    \cs_new:cpn {#1approximatevalue} {#3}
    \cs_new:cpn {#1precisevalue} {#4}
    \cs_new:cpn {#1baseunits}
      {\units{\mandi@selectprecision{#3}{#4}}{\mandi@selectbaseunits{#5}{#6}{#7}}}
    \cs_new:cpn {#1derivedunits}
      {\units{\mandi@selectprecision{#3}{#4}}{\mandi@selectderivedunits{#5}{#6}{#7}}}
    \cs_new:cpn {#1alternateunits}
      {\units{\mandi@selectprecision{#3}{#4}}{\mandi@selectalternateunits{#5}{#6}{#7}}}
    \cs_new:cpn {#1onlybaseunits} {\mandi@selectbaseunits{#5}{#6}{#7}}
    \cs_new:cpn {#1onlyderivedunits} {\mandi@selectderivedunits{#5}{#6}{#7}}
    \cs_new:cpn {#1onlyalternateunits} {\mandi@selectalternateunits{#5}{#6}{#7}}
  }
\NewDocumentCommand{\NewPhysicalConstant}{ m m m m m O{#5} O{#5} }
  {
    \__mandi_newphysicalconstant:nnnnnnn { #1 }{ #2 }{ #3 }{ #4 }{ #5 }{ #6 }{ #7 }
  }
\ExplSyntaxOff
```

Redefining an existing physical constant.

```
\ExplSyntaxOn
\cs_new:Npn \__mandi_renewphysicalconstant:nnnnnnn #1#2#3#4#5#6#7
  {
    \cs_set:cpn {#1} {\units{\mandi@selectprecision{#3}{#4}}{\mandi@selectunits{#5}{#6}{#7}}}
    \cs_set:cpn {#1mathsymbol} {#2}
    \cs_set:cpn {#1approximatevalue} {#3}
    \cs_set:cpn {#1precisevalue} {#4}
    \cs_set:cpn {#1baseunits}
      {\units{\mandi@selectprecision{#3}{#4}}{\mandi@selectbaseunits{#5}{#6}{#7}}}
    \cs_set:cpn {#1derivedunits}
      {\units{\mandi@selectprecision{#3}{#4}}{\mandi@selectderivedunits{#5}{#6}{#7}}}
    \cs_set:cpn {#1alternateunits}
      {\units{\mandi@selectprecision{#3}{#4}}{\mandi@selectalternateunits{#5}{#6}{#7}}}
    \cs_set:cpn {#1onlybaseunits} {\mandi@selectbaseunits{#5}{#6}{#7}}
    \cs_set:cpn {#1onlyderivedunits} {\mandi@selectderivedunits{#5}{#6}{#7}}
    \cs_set:cpn {#1onlyalternateunits} {\mandi@selectalternateunits{#5}{#6}{#7}}
  }
\NewDocumentCommand{\RenewPhysicalConstant}{ m m m m m O{#5} O{#5} }
  {
    \__mandi_renewphysicalconstant:nnnnnnn { #1 }{ #2 }{ #3 }{ #4 }{ #5 }{ #6 }{ #7 }
  }
\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.

```
\NewVectorQuantity{acceleration}%
  {\meter\usk\second\totheinversetwo}%
  [\newton\per\kilogram]%
  [\meter\per\second\tothetwo]%
```

```
\NewScalarQuantity{amount}%
  {\mole}%
\NewVectorQuantity{angularacceleration}%
  {\radian\usk\second\totheinversetwo}%
  [\radian\per\second\tothetwo]%
  [\radian\per\second\tothetwo]%
\NewScalarQuantity{angularfrequency}%
  {\radian\usk\second\inverse}%
  [\radian\per\second]%
  [\radian\per\second]%
```

Angular impulse may also be `\newton\usk\meter\usk\second` or `\joule\usk\second`.

```
\NewVectorQuantity{angularimpulse}%
  {\kilogram\usk\meter\tothetwo\usk\second\inverse}%
  [\kilogram\usk\meter\tothetwo\per\second]%
  [\kilogram\usk\meter\tothetwo\per\second]%
```

Angular momentum may also be `\joule\usk\second` or `\newton\usk\meter\usk\second`.

```
\NewVectorQuantity{angularmomentum}%
  {\kilogram\usk\meter\tothetwo\usk\second\inverse}%
  [\kilogram\usk\meter\tothetwo\per\second]%
  [\kilogram\usk\meter\tothetwo\per\second]%
```

```
\NewVectorQuantity{angularvelocity}%
  {\radian\usk\second\inverse}%
  [\radian\per\second]%
  [\radian\per\second]%
\NewScalarQuantity{area}%
  {\meter\tothetwo}%
\NewScalarQuantity{areachargedensity}%
  {\ampere\usk\second\usk\meter\totheinversetwo}%
  [\coulomb\per\meter\tothetwo]%
  [\coulomb\per\meter\tothetwo]%
\NewScalarQuantity{areamassdensity}%
  {\kilogram\usk\meter\totheinversetwo}%
  [\kilogram\per\meter\tothetwo]%
  [\kilogram\per\meter\tothetwo]%
```

Capacitance may also be `\coulomb\tothetwo\per\newton\usk\meter` or `\second\per\ohm`.

```
\NewScalarQuantity{capacitance}%
  {\ampere\tothetwo\usk\second\tothefour\usk\kilogram\inverse\usk\meter\totheinversetwo}%
  [\farad]%
  [\coulomb\per\volt]%
```

Charge may also be `\farad\usk\volt`.

```
\NewScalarQuantity{charge}%
  {\ampere\usk\second}%
  [\coulomb]%
  [\coulomb]%
```

Magnetic field times c may also be `\volt\per\meter`.

```
\NewVectorQuantity{cmagneticfield}%
  {\kilogram\usk\meter\usk\ampere\inverse\usk\second\totheinversethree}%
  [\newton\per\coulomb]%
  [\newton\per\coulomb]%
```

```
\NewScalarQuantity{conductance}%
  {\ampere\tothetwo\usk\second\tothethree\usk\kilogram\inverse\usk\meter\totheinversetwo}%
  [\siemens]%
  [\ampere\per\volt]%
```

```
\NewScalarQuantity{conductivity}%
  {\ampere\tothetwo\usk\second\tothethree\usk\kilogram\inverse\usk\meter\totheinversethree}%
  [\siemens\per\meter]%
  [\ampere\per\volt\usk\meter]%
\NewScalarQuantity{conventionalcurrent}%
  {\ampere}%
  [\coulomb\per\second]%
  [\ampere]%
\NewScalarQuantity{current}%
  {\ampere}%
\NewScalarQuantity{currentdensity}%
  {\ampere\usk\meter\totheinversetwo}%
  [\coulomb\per\second\usk\meter\tothetwo]%
  [\ampere\per\meter\tothetwo]%
\NewScalarQuantity{dielectricconstant}%
  {}%
\NewVectorQuantity{direction}%
  {}%
\NewVectorQuantity{displacement}%
  {\meter}
\NewScalarQuantity{duration}%
  {\second}%
\NewVectorQuantity{electricdipolemoment}%
  {\ampere\usk\second\usk\meter}%
  [\coulomb\usk\meter]%
  [\coulomb\usk\meter]%
\NewVectorQuantity{electricfield}%
  {\kilogram\usk\meter\usk\ampere\inverse\usk\second\totheinversethree}%
  [\volt\per\meter]%
  [\newton\per\coulomb]%
\NewScalarQuantity{electricflux}%
  {\kilogram\usk\meter\tothethree\usk\ampere\inverse\usk\second\totheinversethree}%
  [\volt\usk\meter]%
  [\newton\usk\meter\tothetwo\per\coulomb]%
```

Electric potential, electric potential difference, and emf may also be `\joule\per\coulomb`.

```
\NewScalarQuantity{electricpotential}%
  {\kilogram\usk\meter\tothetwo\usk\ampere\inverse\usk\second\totheinversethree}%
  [\volt]%
  [\volt]%
```

```
\NewScalarQuantity{electricpotentialdifference}%
  {\kilogram\usk\meter\tothetwo\usk\ampere\inverse\usk\second\totheinversethree}%
  [\volt]%
  [\volt]%
\NewScalarQuantity{electroncurrent}%
  {\second\inverse}%
  [\ensuremath{\symup{e}}\per\second]%
  [\ensuremath{\symup{e}}\per\second]%
\NewScalarQuantity{emf}%
  {\kilogram\usk\meter\tothetwo\usk\ampere\inverse\usk\second\totheinversethree}%
  [\volt]%
  [\volt]%
```

Energy may also be `\newton\usk\meter`.

```
\NewScalarQuantity{energy}%
  {\kilogram\usk\meter\tothetwo\usk\second\totheinversetwo}%
  [\joule]%
  [\joule]%
```

```
\NewScalarQuantity{energyinev}%
  {\electronvolt}%
\NewScalarQuantity{energyinkev}%
  {\kiloelectronvolt}%
\NewScalarQuantity{energyinmev}%
  {\megaelectronvolt}%
\NewScalarQuantity{energydensity}%
  {\kilogram\usk\meter\inverse\usk\second\totheinversetwo}%
  [\joule\per\meter\tothethree]%
  [\joule\per\meter\tothethree]%
\NewScalarQuantity{energyflux}%
  {\kilogram\usk\second\totheinversethree}%
  [\watt\per\meter\tothetwo]%
  [\watt\per\meter\tothetwo]%
\NewScalarQuantity{entropy}%
  {\kilogram\usk\meter\tothetwo\usk\second\totheinversetwo\usk\kelvin\inverse}%
  [\joule\per\kelvin]%
  [\joule\per\kelvin]%
```

Force may also be `\kilogram\usk\meter\per\second\tothetwo`.

```
\NewVectorQuantity{force}%
  {\kilogram\usk\meter\usk\second\totheinversetwo}%
  [\newton]%
  [\newton]%
```

```
\NewScalarQuantity{frequency}%
  {\second\inverse}%
  [\hertz]%
  [\hertz]%
\NewVectorQuantity{gravitationalfield}%
  {\meter\usk\second\totheinversetwo}%
  [\newton\per\kilogram]%
  [\newton\per\kilogram]%
\NewScalarQuantity{gravitationalpotential}%
  {\meter\tothetwo\usk\second\totheinversetwo}%
  [\joule\per\kilogram]%
  [\joule\per\kilogram]%
\NewScalarQuantity{gravitationalpotentialdifference}%
  {\meter\tothetwo\usk\second\totheinversetwo}%
  [\joule\per\kilogram]%
  [\joule\per\kilogram]%
\NewVectorQuantity{impulse}%
  {\kilogram\usk\meter\usk\second\inverse}%
  [\newton\usk\second]%
  [\newton\usk\second]%
\NewScalarQuantity{indexofrefraction}%
  {}%
```

Inductance may also be `\square\meter\usk\kilogram\per\coulomb\tothetwo` or `\Wb\per\ampere`.

```
\NewScalarQuantity{inductance}%
  {\kilogram\usk\meter\tothetwo\usk\ampere\totheinversetwo\usk\second\totheinversetwo}%
  [\henry]%
  [\volt\usk\second\per\ampere]%
```

```
\NewScalarQuantity{linearchargedensity}%
  {\ampere\usk\second\usk\meter\inverse}%
  [\coulomb\per\meter]%
  [\coulomb\per\meter]%
\NewScalarQuantity{linearmassdensity}%
  {\kilogram\usk\meter\inverse}%
```

```
  [\kilogram\per\meter]%
  [\kilogram\per\meter]%
```

```
\NewScalarQuantity{lorentzfactor}%
  {}%
\NewScalarQuantity{luminousintensity}%
  {\candela}%
```

There is another convention for magnetic charge, so be careful.

```
\NewScalarQuantity{magneticcharge}%
  {\ampere\usk\meter}%
```

```
\NewVectorQuantity{magneticdipolemoment}%
  {\ampere\usk\meter\tothetwo}%
  [\ampere\usk\meter\tothetwo]%
  [\joule\per\tesla]%
```

Magnetic field may also be `\Wb\per\meter\tothetwo`.

```
\NewVectorQuantity{magneticfield}%
  {\kilogram\usk\ampere\inverse\usk\second\totheinversetwo}%
  [\newton\per\ampere\usk\meter]%
  [\tesla]%
```

Magnetic flux may also be `\Wb` or `\joule\per\ampere`.

```
\NewScalarQuantity{magneticflux}%
  {\kilogram\usk\meter\tothetwo\usk\ampere\inverse\usk\second\totheinversetwo}%
  [\tesla\usk\meter\tothetwo]%
  [\volt\usk\second]%
```

```
\NewScalarQuantity{mass}%
  {\kilogram}%
\NewScalarQuantity{mobility}%
  {\kilogram\usk\meter\tothetwo\usk\ampere\inverse\usk\second\totheinversefour}%
  [\meter\tothetwo\per\volt\usk\second]%
  [\coulomb\usk\meter\per\newton\usk\second]%
\NewScalarQuantity{momentofinertia}%
  {\kilogram\usk\meter\tothetwo}%
  [\joule\usk\second\tothetwo]%
  [\kilogram\usk\meter\tothetwo]%
\NewVectorQuantity{momentum}%
  {\kilogram\usk\meter\usk\second\inverse}%
  [\kilogram\usk\meter\per\second]%
  [\kilogram\usk\meter\per\second]%
\NewVectorQuantity{momentumflux}%
  {\kilogram\usk\meter\inverse\usk\second\totheinversetwo}%
  [\newton\per\meter\tothetwo]%
  [\newton\per\meter\tothetwo]%
\NewScalarQuantity{numberdensity}%
  {\meter\totheinversethree}%
  [\per\meter\tothethree]%
  [\per\meter\tothethree]%
\NewScalarQuantity{permeability}%
  {\kilogram\usk\meter\usk\ampere\totheinversetwo\usk\second\totheinversetwo}%
  [\henry\per\meter]%
  [\tesla\usk\meter\per\ampere]%
\NewScalarQuantity{permittivity}%
  {\ampere\tothetwo\usk\second\tothefour\usk\kilogram\inverse\usk\meter\totheinversethree}%
  [\farad\per\meter]%
  [\coulomb\tothetwo\per\newton\usk\meter\tothetwo]%
\NewScalarQuantity{planeangle}%
```

```
  {\meter\usk\meter\inverse}%
  [\radian]%
  [\radian]%
\NewScalarQuantity{polarizability}%
  {\ampere\tothetwo\usk\second\tothefour\usk\kilogram\inverse}%
  [\coulomb\usk\meter\tothetwo\per\volt]%
  [\coulomb\tothetwo\usk\meter\per\newton]%
\NewScalarQuantity{power}%
  {\kilogram\usk\meter\tothetwo\usk\second\totheinversethree}%
  [\watt]%
  [\joule\per\second]%
\NewVectorQuantity{poynting}%
  {\kilogram\usk\second\totheinversethree}%
  [\watt\per\meter\tothetwo]%
  [\watt\per\meter\tothetwo]%
\NewScalarQuantity{pressure}%
  {\kilogram\usk\meter\inverse\usk\second\totheinversetwo}%
  [\pascal]%
  [\newton\per\meter\tothetwo]%
\NewScalarQuantity{relativepermeability}
  {}%
\NewScalarQuantity{relativepermittivity}%
  {}%
```

Resistance may also be \volt\per\ampere.

```
\NewScalarQuantity{resistance}%
  {\kilogram\usk\meter\tothetwo\usk\ampere\totheinversetwo\usk\second\totheinversethree}%
  [\ohm]%
  [\ohm]%
```

```
\NewScalarQuantity{resistivity}%
  {\kilogram\usk\meter\tothethree\usk\ampere\totheinversetwo\usk\second\totheinversethree}%
  [\ohm\usk\meter]%
  [\volt\usk\meter\per\ampere]%
\NewScalarQuantity{solidangle}%
  {\meter\tothetwo\usk\meter\totheinversetwo}%
  [\steradian]%
  [\steradian]%
\NewScalarQuantity{specificheatcapacity}%
  {\meter\tothetwo\usk\second\totheinversetwo\usk\kelvin\inverse}%
  [\joule\per\kelvin\usk\kilogram]%
  [\joule\per\kelvin\usk\kilogram]
\NewScalarQuantity{springstiffness}%
  {\kilogram\usk\second\totheinversetwo}%
  [\newton\per\meter]%
  [\newton\per\meter]%
```

Spring stretch is really just a displacement.

```
\NewScalarQuantity{springstretch}%
  {\meter}%
```

```
\NewScalarQuantity{stress}%
  {\kilogram\usk\meter\inverse\usk\second\totheinversetwo}%
  [\pascal]%
  [\newton\per\meter\tothetwo]%
\NewScalarQuantity{strain}%
  {}%
\NewScalarQuantity{temperature}%
  {\kelvin}%
\NewVectorQuantity{torque}%
```

```
  {\kilogram\usk\meter\tothetwo\usk\second\totheinversetwo}%
  [\newton\usk\meter]%
  [\newton\usk\meter]%
\NewVectorQuantity{velocity}%
  {\meter\usk\second\inverse}%
  [\meter\per\second]%
  [\meter\per\second]%
\NewVectorQuantity{velocityc}%
  {\lightspeed}%
  [\lightspeed]%
  [\lightspeed]%
\NewScalarQuantity{volume}%
  {\meter\tothethree}%
\NewScalarQuantity{volumechargedensity}%
  {\ampere\usk\second\per\meter\totheinversethree}%
  [\coulomb\per\meter\tothethree]%
  [\coulomb\per\meter\tothethree]%
\NewScalarQuantity{volumemassdensity}%
  {\kilogram\usk\meter\totheinversethree}%
  [\kilogram\per\meter\tothethree]%
  [\kilogram\per\meter\tothethree]%
```

Wavelength is really just a displacement.

```
\NewScalarQuantity{wavelength}%
  {\meter}%
```

```
\NewVectorQuantity{wavenumber}%
  {\meter\inverse}%
  [\per\meter]%
  [\per\meter]%
```

Work may also be `\newton\usk\meter` but this is discouraged to avoid confusion with torque.

```
\NewScalarQuantity{work}%
  {\kilogram\usk\meter\tothetwo\usk\second\totheinversetwo}%
  [\joule]%
  [\joule]%
```

Young's modulus is really just a stress.

```
\NewScalarQuantity{youngsmodulus}%
  {\kilogram\usk\meter\inverse\usk\second\totheinversetwo}%
  [\pascal]%
  [\newton\per\meter\tothetwo]%
```

We need a better glyph for Planck's constant over 2π.

```
\AtBeginDocument{%
  \DeclareRobustCommand{\hbar}{{\mathpalette\hbar@\relax\symup{h}}}%
}%
\newcommand*{\hbar@}[2]{%
  \makebox[0pt][l]{\raisebox{-0.07\height}{\(\m@th#1\mkern-2mu\mathchar"AF\)}}%
```

Optional line to make the bar thicker; must use -0.11 in `\raisebox`.

```
  \makebox[0pt][l]{\raisebox{-0.11\height}{\(\m@th#1\mkern-2mu\mathchar"AF\)}}%
}%
```

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

```
\NewPhysicalConstant{avogadro}%
  {\symup{N_{A}}}%
  {6\times10^{23}}{6.02214076\times10^{23}}%
  {\mole\inverse}%
  [\per\mole]%
  [\per\mole]%
```

\biotsavartconstant is an alias for \mzofp.

```
\NewPhysicalConstant{biotsavartconstant}%
  {\symup{\frac{\mu_{o}}{4\pi}}}%
  {10^{-7}}{10^{-7}}%
  {\kilogram\usk\meter\usk\ampere\totheinversetwo\usk\second\totheinversetwo}%
  [\henry\per\meter]%
  [\tesla\usk\meter\per\ampere]%
\NewPhysicalConstant{bohrradius}%
  {\symup{a_{o}}}%
  {5.3\times10^{-11}}{5.29177210903\times10^{-11}}%
  {\meter}%
\NewPhysicalConstant{boltzmann}%
  {\symup{k_{B}}}%
  {1.4\times10^{-23}}{1.380649\times10^{-23}}%
  {\kilogram\usk\meter\tothetwo\usk\second\totheinversetwo\usk\kelvin\inverse}%
  [\joule\per\kelvin]%
  [\joule\per\kelvin]%
```

\coulombconstant is an alias for \oofpez.

```
\NewPhysicalConstant{coulombconstant}%
  {\symup{\frac{1}{4\pi\epsilon_{o}}}}%
  {9\times10^{9}}{8.9875517923\times10^{9}}%
  {\kilogram\usk\meter\tothethree\usk\ampere\totheinversetwo\usk\second\totheinversefour}%
  [\meter\per\farad]%
  [\newton\usk\meter\tothetwo\per\coulomb\tothetwo]%
\NewPhysicalConstant{earthmass}%
  {\symup{M_{Earth}}}%
  {6.0\times10^{24}}{5.9722\times10^{24}}%
  {\kilogram}%
\NewPhysicalConstant{earthmoondistance}%
  {\symup{d_{EM}}}%
  {3.8\times10^{8}}{3.81550\times10^{8}}%
  {\meter}%
\NewPhysicalConstant{earthradius}%
  {\symup{R_{Earth}}}%
  {6.4\times10^{6}}{6.3781\times10^{6}}%
  {\meter}%
\NewPhysicalConstant{earthsundistance}%
  {\symup{d_{ES}}}%
  {1.5\times10^{11}}{1.496\times10^{11}}%
  {\meter}%
\NewPhysicalConstant{electroncharge}%
  {\symup{q_{e}}}%
  {-\elementarychargeapproximatevalue}{-\elementarychargeprecisevalue}%
  {\ampere\usk\second}%
  [\coulomb]%
  [\coulomb]%
\NewPhysicalConstant{electronCharge}%
  {\symup{Q_{e}}}%
  {-\elementarychargeapproximatevalue}{-\elementarychargeprecisevalue}%
  {\ampere\usk\second}%
  [\coulomb]%
  [\coulomb]%
\NewPhysicalConstant{electronmass}%
  {\symup{m_{e}}}%
  {9.1\times10^{-31}}{9.1093837015\times10^{-31}}%
  {\kilogram}%
\NewPhysicalConstant{elementarycharge}%
  {\symup{e}}%
```

```
  {1.6\times10^{-19}}{1.602176634\times10^{-19}}%
  {\ampere\usk\second}%
  [\coulomb]%
  [\coulomb]%
\NewPhysicalConstant{finestructure}%
  {\symup{\alpha}}%
  {\frac{1}{137}}{7.2973525693\times10^{-3}}%
  {}%
\NewPhysicalConstant{hydrogenmass}%
  {\symup{m_{H}}}%
  {1.7\times10^{-27}}{1.6737236\times10^{-27}}%
  {\kilogram}%
\NewPhysicalConstant{moonearthdistance}%
  {\symup{d_{ME}}}%
  {3.8\times10^{8}}{3.81550\times10^{8}}%
  {\meter}%
\NewPhysicalConstant{moonmass}%
  {\symup{M_{Moon}}}%
  {7.3\times10^{22}}{7.342\times10^{22}}%
  {\kilogram}%
\NewPhysicalConstant{moonradius}%
  {\symup{R_{Moon}}}%
  {1.7\times10^{6}}{1.7371\times10^{6}}%
  {\meter}%
\NewPhysicalConstant{mzofp}%
  {\symup{\frac{\mu_{o}}{4\pi}}}%
  {10^{-7}}{10^{-7}}%
  {\kilogram\usk\meter\usk\ampere\totheinversetwo\usk\second\totheinversetwo}%
  [\henry\per\meter]%
  [\tesla\usk\meter\per\ampere]%
\NewPhysicalConstant{neutronmass}%
  {\symup{m_{n}}}%
  {1.7\times10^{-27}}{1.67492749804\times10^{-27}}%
  {\kilogram}%
\NewPhysicalConstant{oofpez}%
  {\symup{\frac{1}{4\pi\epsilon_{o}}}}%
  {9\times10^{9}}{8.9875517923\times10^{9}}%
  {\kilogram\usk\meter\tothethree\usk\ampere\totheinversetwo\usk\second\totheinversefour}%
  [\meter\per\farad]%
  [\newton\usk\meter\tothetwo\per\coulomb\tothetwo]%
\NewPhysicalConstant{oofpezcs}%
  {\symup{\frac{1}{4\pi\epsilon_{o} c^2}}}%
  {10^{-7}}{10^{-7}}%
  {\kilogram\usk\meter\usk\ampere\totheinversetwo\usk\second\totheinversetwo}%
  [\tesla\usk\meter\tothetwo]%
  [\newton\usk\second\tothetwo\per\coulomb\tothetwo]%
\NewPhysicalConstant{planck}%
  {\symup{h}}%
  {6.6\times10^{-34}}{6.62607015\times10^{-34}}%
  {\kilogram\usk\meter\tothetwo\usk\second\inverse}%
  [\joule\usk\second]%
  [\joule\usk\second]%
```

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

```
\NewPhysicalConstant{planckbar}%
  {\hbar}%
  {1.1\times10^{-34}}{1.054571817\times10^{-34}}%
  {\kilogram\usk\meter\tothetwo\usk\second\inverse}%
  [\joule\usk\second]%
```

```
  [\joule\usk\second]
\NewPhysicalConstant{planckc}%
  {\symup{hc}}%
  {2.0\times10^{-25}}{1.98644586\times10^{-25}}%
  {\kilogram\usk\meter\tothethree\usk\second\totheinversetwo}%
  [\joule\usk\meter]%
  [\joule\usk\meter]%
\NewPhysicalConstant{protoncharge}%
  {\symup{q_p}}%
  {+\elementarychargeapproximatevalue}{+\elementarychargeprecisevalue}%
  {\ampere\usk\second}%
  [\coulomb]%
  [\coulomb]%
\NewPhysicalConstant{protonCharge}%
  {\symup{Q_p}}%
  {+\elementarychargeapproximatevalue}{+\elementarychargeprecisevalue}%
  {\ampere\usk\second}%
  [\coulomb]%
  [\coulomb]%
\NewPhysicalConstant{protonmass}%
  {\symup{m_p}}%
  {1.7\times10^{-27}}{1.672621898\times10^{-27}}%
  {\kilogram}%
\NewPhysicalConstant{rydberg}%
  {\symup{R_{\infty}}}%
  {1.1\times10^{7}}{1.0973731568160\times10^{7}}%
  {\meter\inverse}%
\NewPhysicalConstant{speedoflight}%
  {\symup{c}}%
  {3\times10^{8}}{2.99792458\times10^{8}}%
  {\meter\usk\second\inverse}%
  [\meter\per\second]%
  [\meter\per\second]
\NewPhysicalConstant{stefanboltzmann}%
  {\symup{\sigma}}%
  {5.7\times10^{-8}}{5.670374\times10^{-8}}%
  {\kilogram\usk\second\totheinversethree\usk\kelvin\totheinversefour}%
  [\watt\per\meter\tothetwo\usk\kelvin\tothefour]%
  [\watt\per\meter\tothetwo\usk\kelvin\tothefour]
\NewPhysicalConstant{sunearthdistance}%
  {\symup{d_{SE}}}%
  {1.5\times10^{11}}{1.496\times10^{11}}%
  {\meter}%
\NewPhysicalConstant{sunmass}%
  {\symup{M_{Sun}}}%
  {2.0\times10^{30}}{1.98855\times10^{30}}%
  {\kilogram}%
\NewPhysicalConstant{sunradius}%
  {\symup{R_{Sun}}}%
  {7.0\times10^{8}}{6.957\times10^{8}}%
  {\meter}%
\NewPhysicalConstant{surfacegravfield}%
  {\symup{g}}%
  {9.8}{9.807}%
  {\meter\usk\second\totheinversetwo}%
  [\newton\per\kilogram]%
  [\newton\per\kilogram]%
```

The gravitational constant may also have units of `\joule\usk\meter\per\kilogram\tothetwo`.

```
\NewPhysicalConstant{universalgrav}%
  {\symup{G}}%
  {6.7\times10^{-11}}{6.67430\times10^{-11}}%
  {\meter\tothethree\usk\kilogram\inverse\usk\second\totheinversetwo}%
  [\newton\usk\meter\tothetwo\per\kilogram\tothetwo]%
  [\newton\usk\meter\tothetwo\per\kilogram\tothetwo]%
```

As of 2018 the vacuum permeability is no longer defined as $4\pi \times 10^{-7}$.

```
\NewPhysicalConstant{vacuumpermeability}%
  {\symup{\mu_o}}%
  {4\pi\times10^{-7}}{4\pi\times10^{-7}}%
  {\kilogram\usk\meter\usk\ampere\totheinversetwo\usk\second\totheinversetwo}%
  [\henry\per\meter]%
  [\tesla\usk\meter\per\ampere]%
\NewPhysicalConstant{vacuumpermittivity}%
  {\symup{\epsilon_o}}%
  {9\times10^{-12}}{8.854187817\times10^{-12}}%
  {\ampere\tothetwo\usk\second\tothefour\usk\kilogram\inverse\usk\meter\totheinversethree}%
  [\farad\per\meter]%
  [\coulomb\tothetwo\per\newton\usk\meter\tothetwo]%
```

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

```
\ExplSyntaxOn
\NewDocumentCommand{\@aux}{ m }
  {
    \use:c { #1 }
  }
\NewDocumentCommand{\@auy}{ m }
  {
    \normalfont\ttfamily\token_to_str:c { #1 }
  }
\ExplSyntaxOff
\newcolumntype{M}{>{\(}p{0.25\linewidth}<{\)}}
\NewDocumentCommand{\CheckQuantity}{ m }
  {%
    \begin{center}
      \begin{tabular}{MMM}
        \textbf{command}       & \multicolumn{2}{l}{\@auy{#1}}                             \tabularnewline
        \text{\textbf{base}}   & \text{\textbf{derived}}     & \text{\textbf{alternate}}   \tabularnewline
        \@aux{#1onlybaseunits} & \@aux{#1onlyderivedunits}   & \@aux{#1onlyalternateunits} \tabularnewline
      \end{tabular}
    \end{center}
  }%
\NewDocumentCommand{\CheckConstant}{ m }
  {%
    \begin{center}
      \begin{tabular}{MMM}
        \textbf{command}       & \multicolumn{2}{l}{\@auy{#1}}                             \tabularnewline
        \text{\textbf{symbol}} & \text{\textbf{approximate}} & \text{\textbf{precise}}     \tabularnewline
        \@aux{#1mathsymbol}    & \@aux{#1approximatevalue}   & \@aux{#1precisevalue}       \tabularnewline
        \text{\textbf{base}}   & \text{\textbf{derived}}     & \text{\textbf{alternate}}   \tabularnewline
        \@aux{#1onlybaseunits} & \@aux{#1onlyderivedunits}   & \@aux{#1onlyalternateunits} \tabularnewline
      \end{tabular}
    \end{center}
  }%
```

`\mivector`→P. 34 is a workhorse command.
See https://tex.stackexchange.com/a/39054/218142.

```
\ExplSyntaxOn
```

```
\NewDocumentCommand{\mivector}{ O{,} m o }
  {
    \__mandi_vector:nn { #1 } { #2 }
    \IfValueT{#3}{\,{#3}}
  }
\seq_new:N \l__mandi_list_seq
\cs_new_protected:Npn \__mandi_vector:nn #1#2
  {
      \seq_set_split:Nnn \l__mandi_list_seq { , } { #2 }
      \int_compare:nT { \seq_count:N \l__mandi_list_seq = 1 }
       {
         \msg_new:nnnn { mandi } { onecomponent }
           {
             More~than~one~component~expected.       \iow_newline:
             You~provided~one~component~to~a~command \iow_newline:
             that~expects~a~vector.~Either~you~don't \iow_newline:
             need~a~vector~here~or~you~didn't~supply \iow_newline:
             all~the~components.
           }
           {
             Decide~whether~or~not~you~really~need~a~vector~command~here. \iow_newline:
             \msg_see_documentation_text:n { mandi }
           }
         \msg_fatal:nn { mandi } { onecomponent }

       }
      \left\langle
        \seq_use:Nnnn \l__mandi_list_seq { #1 } { #1 } { #1 }
      \right\rangle
  }
\ExplSyntaxOff
```

7 The mandistudent Package

mandi comes with an accessory package mandistudent, which extends mandi with 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. 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 v3.2.0 dated 2023-08-01 and is a stable build.

7.1 Traditional Vector Notation

U 2021-09-18 **\vec**{⟨*symbol*⟩}[⟨*labels*⟩] (use this variant for boldface notation)

U 2021-09-18 **\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 2ε `\vec` command.

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

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

U 2021-09-18 **\dirvec**{⟨*symbol*⟩}[⟨*labels*⟩] (use this variant for boldface notation)

U 2021-09-18 **\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.

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

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

\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.

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

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

N 2021-02-21 **\doublebars[⟨*size*⟩]{⟨*quantity*⟩}** (double bars)
N 2021-02-21 **\doublebars*[⟨*size*⟩]{⟨*quantity*⟩}** (double bars for fractions)
N 2021-02-21 **\singlebars[⟨*size*⟩]{⟨*quantity*⟩}** (single bars)
N 2021-02-21 **\singlebars*[⟨*size*⟩]{⟨*quantity*⟩}** (single bars for fractions)
N 2021-02-21 **\anglebrackets[⟨*size*⟩]{⟨*quantity*⟩}** (angle brackets)
N 2021-02-21 **\anglebrackets*[⟨*size*⟩]{⟨*quantity*⟩}** (angle brackets for fractions)
N 2021-02-21 **\parentheses[⟨*size*⟩]{⟨*quantity*⟩}** (parentheses)
N 2021-02-21 **\parentheses*[⟨*size*⟩]{⟨*quantity*⟩}** (parentheses for fractions)
N 2021-02-21 **\squarebrackets[⟨*size*⟩]{⟨*quantity*⟩}** (square brackets)
N 2021-02-21 **\squarebrackets*[⟨*size*⟩]{⟨*quantity*⟩}** (square brackets for fractions)

N 2021-02-21 `\curlybraces[⟨size⟩]{⟨quantity⟩}` (curly braces)

N 2021-02-21 `\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.

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

$$\lVert \cdot \rVert$$
$$\lVert \boldsymbol{a} \rVert$$
$$\left\lVert \frac{\boldsymbol{a}}{3} \right\rVert$$
$$\Bigg\lVert \frac{\boldsymbol{a}}{3} \Bigg\rVert$$

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

$$\lvert \cdot \rvert$$
$$\lvert x \rvert$$
$$\left\lvert \frac{x}{3} \right\rvert$$
$$\Bigg\lvert \frac{x}{3} \Bigg\rvert$$

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

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

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

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

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

$$[\,\cdot\,]$$
$$[x]$$
$$\left[\frac{x}{3}\right]$$
$$\Bigg[\frac{x}{3}\Bigg]$$

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

$$\{\,\cdot\,\}$$
$$\{x\}$$
$$\left\{\frac{x}{3}\right\}$$
$$\Bigg\{\frac{x}{3}\Bigg\}$$

N 2021-02-21 **\magnitude**[⟨*size*⟩]{⟨*quantity*⟩} (alias for double bars)
N 2021-02-21 **\magnitude***[⟨*size*⟩]{⟨*quantity*⟩} (alias for double bars for fractions)
N 2021-02-21 **\norm**[⟨*size*⟩]{⟨*quantity*⟩} (alias for double bars)
N 2021-02-21 **\norm***[⟨*size*⟩]{⟨*quantity*⟩} (alias for double bars for fractions)
N 2021-02-21 **\absolutevalue**[⟨*size*⟩]{⟨*quantity*⟩} (alias for single bars)
N 2021-02-21 **\absolutevalue***[⟨*size*⟩]{⟨*quantity*⟩} (alias for single bars for fractions)

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

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

$$\|\boldsymbol{p}\|$$
$$\|\vec{p}\|$$
$$\left\|\boldsymbol{p}_{\mathrm{final}}\right\|$$
$$\left\|\vec{p}_{\mathrm{final}}\right\|$$

N 2021-04-06 **\parallelto**
N 2021-04-06 **\perpendicularto**

Commands for geometric relationships, mainly intended for subscripts.

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

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

7.2 Problems and Annotated Problem Solutions

U 2023-08-01 \begin{physicsproblem}{⟨*title*⟩} (use this variant for vertical lists)
⟨*problem*⟩
\end{physicsproblem}

U 2023-08-01 \begin{physicsproblem*}{⟨*title*⟩} (use this variant for in-line lists)
⟨*problem*⟩
\end{physicsproblem*}

U 2023-08-01 \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. Due to incompatibilities with BEAMER and the enumitem package, these environments are not defined if BEAMER is loaded.

U 2023-08-01 \problempart

Denotes a part of a problem within a parts environment. This command is not defined if BEAMER is loaded.

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

Problem 1

This is a physics problem with no parts.

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

Problem 2

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

(a) This is the first part.

(b) This is the second part.

(c) This is the third part.

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

Problem 3

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

U 2021-02-26 `\begin{physicssolution}` (use this variant for numbered steps)
⟨*solution steps*⟩
`\end{physicssolution}`

U 2021-02-26 `\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*}
```

$$x = y + z \quad (1)$$
$$z = x - y \quad (2)$$
$$y = x - z \quad (3)$$

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

U 2021-02-26 `\reason{`⟨*reason*⟩`}`

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

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

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

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

When writing solutions, remember that the `physicssolution`→P. 57 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}
```

U 2023-08-01 **\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. This command is not defined if BEAMER is loaded.

```
\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*}
```

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

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

$$
\begin{aligned}
\Delta\boldsymbol{p} &= \boldsymbol{F}_{\mathrm{net}}\Delta t \\
\Delta\boldsymbol{p} &= \boldsymbol{F}_{\mathrm{net}}\Delta t \\
\Delta\boldsymbol{p} &= \boldsymbol{F}_{\mathrm{net}}\Delta t \\
\Delta\boldsymbol{p} &= \boldsymbol{F}_{\mathrm{net}}\Delta t \\
\Delta\boldsymbol{p} &= \boldsymbol{F}_{\mathrm{net}}\Delta t \\
\Delta\boldsymbol{p} &= \boldsymbol{F}_{\mathrm{net}}\Delta t
\end{aligned}
$$

U 2021-09-18 **\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}
```

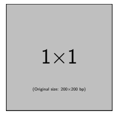

Figure 1: Image shown 20 percent actual size.

```
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 60.

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

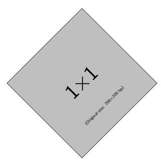

Figure 2: Image shown 20 percent actual size and rotated.

```
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 60.

7.3 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
$\boldsymbol{\mathsf{r}}$
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.

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

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

U 2022-01-27 `\df`

Intelligent differential and exterior derivative operator.

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

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

7.4 Web VPython and VPython Program Listings

`Web VPython` [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.

7.5 The webvpythonblock Environment

U 2023-08-01 `\begin{webvpythonblock}[⟨options⟩](⟨link⟩){⟨caption⟩}` (now includes a QR code)
  ⟨*WebVPython code*⟩
`\end{webvpythonblock}`
U 2023-08-01 `\begin{webvpythonblock*}[⟨options⟩](⟨link⟩){⟨caption⟩}` (use this variant to omit QR code)
  ⟨*WebVPython code*⟩
`\end{webvpythonblock*}`

Code placed here is nicely formatted and optionally linked to its source on `WebVPython.org`, which must be in a public (not private) folder. Clicking anywhere in the code window (between the black horizontal bars) or on the URL 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 especially if it generates an overfull box error. For convenience, `https://` is automatically prepended to the URL and can be omitted. The `#` character in a URL should not cause problems. The default URL is that of the `Web VPython` home page.

[3] On November 9, 2021 `GlowScript` was renamed to `Web VPython`. The website was changed to https://webvpython.org.
[4] https://vpython.org

```
\begin{webvpythonblock}
  (glowscript.org/#/user/heafnerj/folder/mandidemo/program/mandidemo)
  {Example With QR Code}
Web VPython 3.2

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

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

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

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

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

Web VPython Program 1: Example With QR Code
https://glowscript.org/#/user/heafnerj/folder/mandidemo/program/mandidemo

```
Web VPython 3.2

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
```

Here is how one would reference this program elsewhere. Notice the references are numbered sequentially within the document.

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

`Web VPython` program 1 is nice. It's called Example With QR Code and is on page 64.

```
\begin{webvpythonblock*}
  (glowscript.org/#/user/heafnerj/folder/mandidemo/program/mandidemo)
  {Example Without QR Code}
Web VPython 3.2

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

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

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

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

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

Web VPython Program 2: Example Without QR Code
https://glowscript.org/#/user/heafnerj/folder/mandidemo/program/mandidemo

```
Web VPython 3.2

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
```

```
\WebVPython{} program \ref{gs:2} is nice.
It's called \nameref{gs:2} and is on page \pageref{gs:2}.
```

Web VPython program 2 is nice. It's called Example Without QR Code and is on page 67.

7.6 The `vpythonfile` Command

U 2023-08-01 `\vpythonfile[⟨options⟩](⟨link⟩){⟨file⟩}{⟨caption⟩}`

Command to load and typeset a `VPython` program, read from local file `{⟨file⟩}`. Clicking anywhere in the code window (between the black horizontal bars) or on the URL 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 especially if it generates an overfull box error. For convenience, `https://` is automatically prepended to the URL and can be omitted. The default URL is that of the `VPython` home page.

```
\vpythonfile{vdemo.py}{A \VPython{} Program}
```

VPython Program 1: A VPython Program

```
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 69.

7.7 The `webvpythoninline` and `vpythoninline` Commands

U 2021-02-26 **\webvpythoninline**{⟨*Web VPython code*⟩}

U 2021-02-26 **\vpythoninline**{⟨*VPython code*⟩}

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

```
\WebVPython{} programs begin with \webvpythoninline{Web VPython 3.2}.
```

`Web VPython` programs begin with `Web VPython 3.2`.

```
\VPython{} programs begin with \vpythoninline{from vpython import *}.
```

`VPython` programs begin with `from vpython import *`.

7.8 **mandistudent** 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.

```
\def\mandistudent@version{3.2.0}
\def\mandistudent@date{2023-08-01}
\NeedsTeXFormat{LaTeX2e}[2020-02-02]
\DeclareRelease{v3.2.0}{2023-08-01}{mandistudent.sty}
\DeclareCurrentRelease{v\mandistudent@version}{\mandistudent@date}
\ProvidesPackage{mandistudent}
  [\mandistudent@date\space v\mandistudent@version\space Macros for introductory physics]
```

Define a convenient package version command.

```
\newcommand*{\mandistudentversion}{v\mandistudent@version\space dated \mandistudent@date}
```

Load third party packages, documenting why each one is needed.
AMS goodness. Don't load amssymb or amsfonts.

```
\RequirePackage{amsmath}
```

We need enumitem for the `physicsproblem` environment.
BEAMER is not compatible with enumitem so if BEAMER is loaded certain commands are not defined.

```
\IfClassLoadedTF{beamer}%
  {}%
  {%
    \RequirePackage[inline]{enumitem}%
  }%
```

We need eso-pic for `\hilite`.

```
\RequirePackage{eso-pic}
```

We need esvect for nice vector arrows, style g.

```
\RequirePackage[g]{esvect}
```

We need pgfopts for a key-value interface.

```
\RequirePackage{pgfopts}
```

We need iftex so we can require LuaLaTeX.

```
\RequirePackage{iftex}
```

We need makebox for consistent `\dirvect` notation.

```
\RequirePackage{makebox}
```

We need mandi to load mathtools and unicode-math.

```
\IfPackageLoadedTF{mandi}%
  {}%
  {%
    \RequirePackage{mandi}%
  }%
```

We need nicematrix for column and row vectors.

```
\RequirePackage{nicematrix}
```

We need qrcode for QR codes in `webvpythonblock`.

```
\RequirePackage{qrcode}
```

Set the default size for QR codes.

```
\qrset{height=1.5cm}
```

We need tcolorbox for program listings.

```
\RequirePackage[most]{tcolorbox}
```

We need tensor for index notation.

```
\RequirePackage{tensor}
```

```
%
% We need \pkg{tikz} for |\hilite|..
%
\RequirePackage{tikz}
\usetikzlibrary{shapes,fit,tikzmark}
```

Load xparse if necessary.

```
\IfFormatAtLeastTF{2020-10-01}
  {}%
  {\RequirePackage{xparse}}%
```

Always load hyperref last if possible.

```
\RequirePackage{hyperref}
```

We require the LuaLaTeX engine.

```
\RequireLuaTeX
```

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 2_ε kernel. Because unicode-math is required, all documents using mandi must be compiled with an engine that supports Unicode, and I recommend LuaLaTeX.

```
\unimathsetup{math-style=ISO}
```

Use normal math letters from Latin Modern Math for familiarity with textbooks. This gives a better J.

```
\setmathfont[Scale=MatchLowercase]
  {Latin Modern Math}
```

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

```
\setmathfont[Scale=MatchLowercase,range={sfit/{latin},bfsfit/{latin}}]
  {TeX Gyre DejaVu Math}
```

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

```
\setmathfont[Scale=MatchLowercase,range={sfup/{latin},bfsfup/{latin}}]
  {TeX Gyre DejaVu Math}
```

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

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

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

```
\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.

```
\setmathfont[Scale=MatchLowercase,range={"E17C-"E1F6}]{STIX Two Math}
\newfontfamily{\symsfgreek}{STIX Two Math}
```

I don't understand why `\text{...}` is necessary.

```
\newcommand{\symsfupalpha}      {\text{\symsfgreek{^^^^e196}}}
\newcommand{\symsfupbeta}       {\text{\symsfgreek{^^^^e197}}}
\newcommand{\symsfupgamma}      {\text{\symsfgreek{^^^^e198}}}
\newcommand{\symsfupdelta}      {\text{\symsfgreek{^^^^e199}}}
\newcommand{\symsfupepsilon}    {\text{\symsfgreek{^^^^e1af}}}
```

```
\newcommand{\symsfupvarepsilon} {\text{\symsfgreek{^^^^e19a}}}
\newcommand{\symsfupzeta}       {\text{\symsfgreek{^^^^e19b}}}
\newcommand{\symsfupeta}        {\text{\symsfgreek{^^^^e19c}}}
\newcommand{\symsfuptheta}      {\text{\symsfgreek{^^^^e19d}}}
\newcommand{\symsfupvartheta}   {\text{\symsfgreek{^^^^e1b0}}}
\newcommand{\symsfupiota}       {\text{\symsfgreek{^^^^e19e}}}
\newcommand{\symsfupkappa}      {\text{\symsfgreek{^^^^e19f}}}
\newcommand{\symsfuplambda}     {\text{\symsfgreek{^^^^e1a0}}}
\newcommand{\symsfupmu}         {\text{\symsfgreek{^^^^e1a1}}}
\newcommand{\symsfupnu}         {\text{\symsfgreek{^^^^e1a2}}}
\newcommand{\symsfupxi}         {\text{\symsfgreek{^^^^e1a3}}}
\newcommand{\symsfupomicron}    {\text{\symsfgreek{^^^^e1a4}}}
\newcommand{\symsfuppi}         {\text{\symsfgreek{^^^^e1a5}}}
\newcommand{\symsfupvarpi}      {\text{\symsfgreek{^^^^e1b3}}}
\newcommand{\symsfuprho}        {\text{\symsfgreek{^^^^e1a6}}}
\newcommand{\symsfupvarrho}     {\text{\symsfgreek{^^^^e1b2}}}
\newcommand{\symsfupsigma}      {\text{\symsfgreek{^^^^e1a8}}}
\newcommand{\symsfupvarsigma}   {\text{\symsfgreek{^^^^e1a7}}}
\newcommand{\symsfuptau}        {\text{\symsfgreek{^^^^e1a9}}}
\newcommand{\symsfupupsilon}    {\text{\symsfgreek{^^^^e1aa}}}
\newcommand{\symsfupphi}        {\text{\symsfgreek{^^^^e1b1}}}
\newcommand{\symsfupvarphi}     {\text{\symsfgreek{^^^^e1ab}}}
\newcommand{\symsfupchi}        {\text{\symsfgreek{^^^^e1ac}}}
\newcommand{\symsfuppsi}        {\text{\symsfgreek{^^^^e1ad}}}
\newcommand{\symsfupomega}      {\text{\symsfgreek{^^^^e1ae}}}
\newcommand{\symsfupDelta}      {\text{\symsfgreek{^^^^e180}}}
\newcommand{\symsfupGamma}      {\text{\symsfgreek{^^^^e17f}}}
\newcommand{\symsfupTheta}      {\text{\symsfgreek{^^^^e18e}}}
\newcommand{\symsfupLambda}     {\text{\symsfgreek{^^^^e187}}}
\newcommand{\symsfupXi}         {\text{\symsfgreek{^^^^e18a}}}
\newcommand{\symsfupPi}         {\text{\symsfgreek{^^^^e18c}}}
\newcommand{\symsfupSigma}      {\text{\symsfgreek{^^^^e18f}}}
\newcommand{\symsfupUpsilon}    {\text{\symsfgreek{^^^^e191}}}
\newcommand{\symsfupPhi}        {\text{\symsfgreek{^^^^e192}}}
\newcommand{\symsfupPsi}        {\text{\symsfgreek{^^^^e194}}}
\newcommand{\symsfupOmega}      {\text{\symsfgreek{^^^^e195}}}
\newcommand{\symsfitalpha}      {\text{\symsfgreek{^^^^e1d8}}}
\newcommand{\symsfitbeta}       {\text{\symsfgreek{^^^^e1d9}}}
\newcommand{\symsfitgamma}      {\text{\symsfgreek{^^^^e1da}}}
\newcommand{\symsfitdelta}      {\text{\symsfgreek{^^^^e1db}}}
\newcommand{\symsfitepsilon}    {\text{\symsfgreek{^^^^e1f1}}}
\newcommand{\symsfitvarepsilon} {\text{\symsfgreek{^^^^e1dc}}}
\newcommand{\symsfitzeta}       {\text{\symsfgreek{^^^^e1dd}}}
\newcommand{\symsfiteta}        {\text{\symsfgreek{^^^^e1de}}}
\newcommand{\symsfittheta}      {\text{\symsfgreek{^^^^e1df}}}
\newcommand{\symsfitvartheta}   {\text{\symsfgreek{^^^^e1f2}}}
\newcommand{\symsfitiota}       {\text{\symsfgreek{^^^^e1e0}}}
\newcommand{\symsfitkappa}      {\text{\symsfgreek{^^^^e1e1}}}
\newcommand{\symsfitlambda}     {\text{\symsfgreek{^^^^e1e2}}}
\newcommand{\symsfitmu}         {\text{\symsfgreek{^^^^e1e3}}}
\newcommand{\symsfitnu}         {\text{\symsfgreek{^^^^e1e4}}}
\newcommand{\symsfitxi}         {\text{\symsfgreek{^^^^e1e5}}}
\newcommand{\symsfitomicron}    {\text{\symsfgreek{^^^^e1e6}}}
\newcommand{\symsfitpi}         {\text{\symsfgreek{^^^^e1e7}}}
\newcommand{\symsfitvarpi}      {\text{\symsfgreek{^^^^e1f5}}}
\newcommand{\symsfitrho}        {\text{\symsfgreek{^^^^e1e8}}}
\newcommand{\symsfitvarrho}     {\text{\symsfgreek{^^^^e1f4}}}
\newcommand{\symsfitsigma}      {\text{\symsfgreek{^^^^e1ea}}}
\newcommand{\symsfitvarsigma}   {\text{\symsfgreek{^^^^e1e9}}}
```

```
\newcommand{\symsfittau}        {\text{\symsfgreek{^^^^e1eb}}}
\newcommand{\symsfitupsilon}    {\text{\symsfgreek{^^^^e1ec}}}
\newcommand{\symsfitphi}        {\text{\symsfgreek{^^^^e1f3}}}
\newcommand{\symsfitvarphi}     {\text{\symsfgreek{^^^^e1ed}}}
\newcommand{\symsfitchi}        {\text{\symsfgreek{^^^^e1ee}}}
\newcommand{\symsfitpsi}        {\text{\symsfgreek{^^^^e1ef}}}
\newcommand{\symsfitomega}      {\text{\symsfgreek{^^^^e1f0}}}
\newcommand{\symsfitDelta}      {\text{\symsfgreek{^^^^e1c2}}}
\newcommand{\symsfitGamma}      {\text{\symsfgreek{^^^^e1c1}}}
\newcommand{\symsfitTheta}      {\text{\symsfgreek{^^^^e1d0}}}
\newcommand{\symsfitLambda}     {\text{\symsfgreek{^^^^e1c9}}}
\newcommand{\symsfitXi}         {\text{\symsfgreek{^^^^e1cc}}}
\newcommand{\symsfitPi}         {\text{\symsfgreek{^^^^e1ce}}}
\newcommand{\symsfitSigma}      {\text{\symsfgreek{^^^^e1d1}}}
\newcommand{\symsfitUpsilon}    {\text{\symsfgreek{^^^^e1d3}}}
\newcommand{\symsfitPhi}        {\text{\symsfgreek{^^^^e1d4}}}
\newcommand{\symsfitPsi}        {\text{\symsfgreek{^^^^e1d6}}}
\newcommand{\symsfitOmega}      {\text{\symsfgreek{^^^^e1d7}}}
```

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

```
\DeclareFontFamily{U}{esvect}{}
\DeclareFontShape{U}{esvect}{m}{n}{%
  <-5.5> vect5
  <5.5-6.5> vect6
  <6.5-7.5> vect7
  <7.5-8.5> vect8
  <8.5-9.5> vect9
  <9.5-> vect10
}{}%
```

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

```
\typeout{}%
\typeout{mandistudent: You are using mandistudent \mandistudentversion.}%
\typeout{mandistudent: This package requires LuaLaTeX.}%
\typeout{mandistudent: This package changes the default math font(s).}%
\typeout{mandistudent: This package redefines the \protect\vec\space command.}%
\IfClassLoadedTF{beamer}%
  {%
    \typeout{mandistudent: BEAMER detected. Certain commands will not be defined.}%
  }%
  {}%
\typeout{}%
```

A better, intelligent coordinate-free `\vec`→P. 52 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.

```
\RenewDocumentCommand{\vec}{ s m e{_^} }%
  {%
    \IfBooleanTF{#1}
      {%
        \vv{#2}%
        \IfValueT{#4}%
          {\sp{\,#4\vphantom{\smash[t]{\big|}}}}
      }%
      {%
```

```
        \symbfit{#2}
        \IfValueT{#4}%
          {\sp{#4\vphantom{\smash[t]{\big|}}}}
      }%
    \IfValueT{#3}%
      {\sb{#3\vphantom{\smash[b]{|}}}}
  }%
```

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.

```
\NewDocumentCommand{\dirvec}{ s m e{_^} }%
  {%
    \widehat%
      {%
        \makebox*{\(w\)}%
          {%
            \ensuremath{%
              \IfBooleanTF {#1}%
                {%
                  #2%
                }%
                {%
                  \symbfit{#2}%
                }%
            }%
          }%
      }%
    \IfValueT{#3}%
      {\sb{#3\vphantom{\smash[b]{|}}}}%
    \IfValueT{#4}%
      {\sp{\,#4\vphantom{\smash[t]{\big|}}}}%
  }%
```

The zero vector.

```
\NewDocumentCommand{\zerovec}{ s }%
  {%
    \IfBooleanTF {#1}
      {\vv{0}}%
      {\symbfup{0}}%
  }%
```

Notation for column and row vectors.
See https://tex.stackexchange.com/a/39054/218142.

```
\ExplSyntaxOn
\NewDocumentCommand{\colvec}{ O{,} m }
  {
    \__mandi_vectormain:nnnn { p } { \\ } { #1 } { #2 }
  }
\NewDocumentCommand{\rowvec}{ O{,} m }
  {
    \__mandi_vectormain:nnnn { p } { & } { #1 } { #2 }
  }
\seq_new:N \l__mandi_vectorarg_seq
\cs_new_protected:Npn \__mandi_vectormain:nnnn #1#2#3#4
  {
    \seq_set_split:Nnn \l__mandi_vectorarg_seq { #3 } { #4 }
    \begin{#1NiceMatrix}[r]
      \seq_use:Nnnn \l__mandi_vectorarg_seq { #2 } { #2 } { #2 }
    \end{#1NiceMatrix}
```

```
  }
\ExplSyntaxOff
```

Students always need this symbol.

```
\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.

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

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

```
\NewDocumentCommand{\magnitude}{}{\doublebars}
\NewDocumentCommand{\norm}{}{\doublebars}
\NewDocumentCommand{\absolutevalue}{}{\singlebars}
```

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

```
\NewDocumentCommand{\parallelto}{}%
  {%
    \mkern3mu\vphantom{\perp}\vrule depth 0pt\mkern2mu\vrule depth 0pt\mkern3mu%
  }%
\NewDocumentCommand{\perpendicularto}{}{\perp}
```

An environment for problem statements. The starred variant gives in-line lists. These are not defined if BEAMER is loaded.

```
\IfClassLoadedTF{beamer}
  {}%
  {%
    \NewDocumentEnvironment{physicsproblem}{ m }%
      {%
        \newpage%
        \section*{#1}%
        \newlist{parts}{enumerate}{2}%
        \setlist[parts]{label=\bfseries(\alph*)}%
      }%
      {}%
    \NewDocumentEnvironment{physicsproblem*}{ m }%
      {%
        \newpage%
        \section*{#1}%
        \newlist{parts}{enumerate*}{2}%
        \setlist[parts]{label=\bfseries(\alph*)}%
      }%
      {}%
    \NewDocumentCommand{\problempart}{}{\item}%
  }%
```

An environment for problem solutions. Equation numbering is consecutive through the document.

```
\NewDocumentEnvironment{physicssolution}{ +b }%
  {%
    \begin{align}
      #1
    \end{align}
  }%
  {}%
```

```
\NewDocumentEnvironment{physicssolution*}{ +b }%
  {%
    \begin{align*}
      #1
    \end{align*}
  }%
  {}%
```

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

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

Command for highlighting parts of, or entire, mathematical expressions.
This command is not defined if BEAMER is loaded.
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

```
\newcounter{tikzhighlightnode}
\NewDocumentCommand{\hilite}{ O{magenta!60} m O{rectangle} }%
  {%
    \stepcounter{tikzhighlightnode}%
    \tikzmarknode{highlighted-node-\number\value{tikzhighlightnode}}{#2}%
    \edef\temp{%
      \noexpand\AddToShipoutPictureBG{%
        \noexpand\begin{tikzpicture}[overlay,remember picture]%
        \noexpand\iftikzmarkoncurrentpage{highlighted-node-\number\value{tikzhighlightnode}}%
         \noexpand\node[inner sep=1.0pt,fill=#1,#3,fit=(highlighted-node-\number\value{tikzhighlightnode})]{};%
        \noexpand\fi
        \noexpand\end{tikzpicture}%
      }%
    }%
    \temp%
  }%
```

A simplified command for importing images.
See https://tex.stackexchange.com/a/614478/218142.

```
\NewDocumentCommand{\image}{ O{scale=1} m m m }%
  {%
    \par
    \begin{figure}[ht!]
      \centering%
      \includegraphics[#1]{#2}%
      \caption{#3}%
      \label{#4}%
    \end{figure}%
    \par
  }%
```

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.

Consider renaming these to `\vectorsym` and `\tensorsym`.

```
\NewDocumentCommand{\veccomp}{ s m }%
```

```
  {%
    \IfBooleanTF{#1}
      {%
        \symnormal{#2}%
      }%
      {%
        \symbfit{#2}%
      }%
  }%
\NewDocumentCommand{\tencomp}{ s m }%
  {%
    \IfBooleanTF{#1}%
      {%
        \symsfit{#2}%
      }%
      {%
        \symbfsfit{#2}%
      }%
  }%
```

Command to typeset tensor valence.

```
\NewDocumentCommand{\valence}{ s m m }%
  {%
    \IfBooleanTF{#1}%
      {%
        (#2,#3)%
      }%
      {%
        \binom{#2}{#3}%
      }%
  }%
```

Intelligent notation for contraction on pairs of slots.

```
\NewDocumentCommand{\contraction}{ s m }%
  {%
    \IfBooleanTF{#1}
      {%
        \mathsf{C}%
      }%
      {%
        \symbb{C}%
      }%
    _{#2}
  }%
```

Intelligent slot command for coordinate-free tensor notation. `d[]` must be used because of the way consecutive optional arguments are handled. See xparse docs for details.

```
\NewDocumentCommand{\slot}{ s d[] }%
  {%
    \IfBooleanTF{#1}
    {%
      \IfValueTF{#2}
```

Insert a vector, but don't show the slot.

```
      {%
        \smash{\makebox[1.5em]{\ensuremath{#2}}}
      }%
```

No vector, no slot.

```
      {%
        \smash{\makebox[1.5em]{\ensuremath{}}}
      }%
    }%
    {%
      \IfValueTF{#2}
```

Insert a vector and show the slot.

```
        {%
          \underline{\smash{\makebox[1.5em]{\ensuremath{#2}}}}
        }%
```

No vector; just show the slot.

```
        {%
          \underline{\smash{\makebox[1.5em]{\ensuremath{}}}}
        }%
    }%
  }%
```

Intelligent differential (exterior derivative) operator.

```
\NewDocumentCommand{\df}{ s }%
  {%
    \mathop{}\!%
    \IfBooleanTF{#1}%
      {%
        \symbfsfup{d}%
      }%
      {%
        \symsfup{d}%
      }%
  }%
```

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

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

We set a new font for listings and some new colors (background gray, gray, green, orange, peach, pearl, and plum).

```
\newfontfamily{\gsfontfamily}{DejaVuSansMono}
\definecolor{gsbggray}     {rgb}{0.90,0.90,0.90}
\definecolor{gsgray}       {rgb}{0.30,0.30,0.30}
\definecolor{gsgreen}      {rgb}{0.00,0.60,0.00}
\definecolor{gsorange}     {rgb}{0.80,0.45,0.12}
\definecolor{gspeach}      {rgb}{1.00,0.90,0.71}
\definecolor{gspearl}      {rgb}{0.94,0.92,0.84}
\definecolor{gsplum}       {rgb}{0.74,0.46,0.70}
\lstdefinestyle{vpython}%
  {%
    backgroundcolor=\color{gsbggray},%          % background color
    basicstyle=\colordigits\footnotesize,%      % default style
    breakatwhitespace=true%                     % break at whitespace
    breaklines=true,%                           % break long lines
    captionpos=b,%                              % position caption
```

```
    classoffset=1,%                              % STILL DON'T UNDERSTAND THIS
    commentstyle=\color{gsgray},%                % font for comments
    deletekeywords={print},%                     % delete keywords from the given language
    emph={self,cls,@classmethod,@property},%     % words to emphasize
    emphstyle=\color{gsorange}\itshape,%         % font for emphasis
    escapeinside={(*@}{@*)},%                    % add LaTeX within your code
    frame=tb,%                                   % frame style
    framerule=2.0pt,%                            % frame thickness
    framexleftmargin=5pt,%                       % extra frame left margin
    %identifierstyle=\sffamily,%                 % style for identifiers
    keywordstyle=\gsfontfamily\color{gsplum},%   % color for keywords
    language=Python,%                            % select language
    linewidth=\linewidth,%                       % width of listings
    morekeywords={%                              % VPython/Web VPython specific keywords
      __future__,abs,acos,align,ambient,angle,append,append_to_caption,%
      append_to_title,arange,arrow,asin,astuple,atan,atan2,attach_arrow,%
      attach_trail,autoscale,axis,background,billboard,bind,black,blue,border,%
      bounding_box,box,bumpaxis,bumpmap,bumpmaps,camera,canvas,caption,capture,%
      ceil,center,clear,clear_trail,click,clone,CoffeeScript,coils,color,combin,%
      comp,compound,cone,convex,cos,cross,curve,cyan,cylinder,data,degrees,del,%
      delete,depth,descender,diff_angle,digits,division,dot,draw_complete,%
      ellipsoid,emissive,end_face_color,equals,explog,extrusion,faces,factorial,%
      False,floor,follow,font,format,forward,fov,frame,gcurve,gdisplay,gdots,%
      get_library,get_selected,ghbars,global,GlowScript,graph,graphs,green,gvbars,%
      hat,headlength,headwidth,height,helix,hsv_to_rgb,index,interval,keydown,%
      keyup,label,length,lights,line,linecolor,linewidth,logx,logy,lower_left,%
      lower_right,mag,mag2,magenta,make_trail,marker_color,markers,material,%
      max,min,mouse,mousedown,mousemove,mouseup,newball,norm,normal,objects,%
      offset,one,opacity,orange,origin,path,pause,pi,pixel_to_world,pixels,plot,%
      points,pos,pow,pps,print,print_function,print_options,proj,purple,pyramid,%
      quad,radians,radius,random,rate,ray,read_local_file,readonly,red,redraw,%
      retain,rgb_to_hsv,ring,rotate,round,scene,scroll,shaftwidth,shape,shapes,%
      shininess,show_end_face,show_start_face,sign,sin,size,size_units,sleep,%
      smooth,space,sphere,sqrt,start,start_face_color,stop,tan,text,textpos,%
      texture,textures,thickness,title,trail_color,trail_object,trail_radius,%
      trail_type,triangle,trigger,True,twist,unbind,up,upper_left,upper_right,%
      userpan,userspin,userzoom,vec,vector,vertex,vertical_spacing,visible,%
      visual,vpython,VPython,waitfor,Web,VPython,white,width,world,xtitle,%
      yellow,yoffset,ytitle%
    },%
    morekeywords={print,None,TypeError},%        % additional keywords
    morestring=[b]{"""},%                        % treat triple quotes as strings
    numbers=left,%                               % where to put line numbers
    numbersep=10pt,%                             % how far line numbers are from code
    numberstyle=\bfseries\tiny,%                 % set to 'none' for no line numbers
    showstringspaces=false,%                     % show spaces in strings
    showtabs=false,%                             % show tabs within strings
    stringstyle=\gsfontfamily\color{gsgreen},%   % color for strings
    upquote=true,%                               % how to typeset quotes
  }%
```

Introduce a new, more intelligent `webvpythonblock` →P. 62 environment. See https://tex.stackexchange.com/a/232208/218142.

```
\AtBeginEnvironment{webvpythonblock}{\catcode`\#=12}
\AtEndEnvironment{webvpythonblock}{\catcode`\#=6}
\NewTCBListing[auto counter,list inside=gsprogs]{webvpythonblock}{ O{} D(){webvpython.org} m }%
  {%
    breakable,%
    center,%
```

```
    code = \newpage,%
    %derivpeach,%
    enhanced,%
    hyperurl interior = https://#2,%
    label = {gs:\thetcbcounter},%
    left = 8mm,%
    list entry = \thetcbcounter~~~~~#3,%
    listing only,%
    listing style = vpython,%
    nameref = {#3},%
    title = \begin{minipage}{1.5cm}%
              \protect\qrcode*{https://#2}%
            \end{minipage}\hspace{5mm}%
            \begin{minipage}{0.8\textwidth}%
              \texttt{Web VPython} Program \thetcbcounter: #3\\
              \footnotesize{\href{https://#2}{\color{white}{https://#2}}}%
            \end{minipage},%
    width = 0.9\textwidth,%
    {#1},
  }%
```

Here is a variant that omits the QR code.

```
\AtBeginEnvironment{webvpythonblock*}{\catcode`\#=12}
\AtEndEnvironment{webvpythonblock*}{\catcode`\#=6}
\NewTCBListing[use counter from=webvpythonblock,list inside=gsprogs]
  {webvpythonblock*}{ O{} D(){webvpython.org} m }%
    {%
      breakable,%
      center,%
      code = \newpage,%
      %derivpeach,%
      enhanced,%
      hyperurl interior = https://#2,%
      label = {gs:\thetcbcounter},%
      left = 8mm,%
      list entry = \thetcbcounter~~~~~#3,%
      listing only,%
      listing style = vpython,%
      nameref = {#3},%
      title =   \texttt{Web VPython} Program \thetcbcounter: #3\\%
                \footnotesize{\href{https://#2}{\color{white}{https://#2}}},%
      width = 0.9\textwidth,%
      {#1},
    }%
```

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

```
\NewDocumentCommand{\listofwebvpythonprograms}{}%
  {%
    \tcblistof[\section*]{gsprogs}{List of \texttt{Web VPython} Programs}%
  }%
```

Introduce a new, more intelligent `\vpythonfile`→P. 68 command.
See https://tex.stackexchange.com/q/616205/218142.

```
\newcommand*{\vpythonfile}{\catcode`\#=12 \vpythonfile@auxA}
\NewDocumentCommand{\vpythonfile@auxA}{ O{} D(){vpython.org} m m }%
  {%
    \vpythonfile@auxB[#1](#2){#3}{#4}%
    \catcode`\#=6
  }%
```

```
\NewTCBInputListing[auto counter,list inside=vpprogs]
  {\vpythonfile@auxB}{ O{} D(){vpython.org} m m }%
    {%
      breakable,%
      center,%
      code = \newpage,%
      %derivgray,%
      enhanced,%
      hyperurl interior = https://#2,%
      label = {vp:\thetcbcounter},%
      left = 8mm,%
      list entry = \thetcbcounter~~~~~#4,%
      listing file = {#3},%
      listing only,%
      listing style = vpython,%
      nameref = {#4},%
      title = \texttt{VPython} Program \thetcbcounter: #4,%
      width = 0.9\textwidth,%
      {#1},%
    }%
```

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

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

Introduce a new `\webvpythoninline`→P. 70 command.

```
\DeclareTotalTCBox{\webvpythoninline}{ m }%
  {%
    bottom = 0pt,%
    bottomrule = 0.0mm,%
    boxsep = 1.0mm,%
    colback = gsbggray,%
    colframe = gsbggray,%
    left = 0pt,%
    leftrule = 0.0mm,%
    nobeforeafter,%
    right = 0pt,%
    rightrule = 0.0mm,%
    sharp corners,%
    tcbox raise base,%
    top = 0pt,%
    toprule = 0.0mm,%
  }%
  {\lstinline[style = vpython]{#1}}%
```

Define `\vpythoninline`→P. 70, a semantic alias for `VPython` in-line listings.

```
\NewDocumentCommand{\vpythoninline}{}{\webvpythoninline}%
```

8 The mandiexp Package

mandi comes with an accessory package mandiexp which extends mandi with commands specific to *Matter & Interactions*.[5] The commands are primarily for typesetting mathematical expressions used in that text. mandiexp requires, and loads, mandi but mandi doesn't require, and doesn't load, mandiexp. mandiexp requires the `\vec*` command and so loads mandistudent if it has not already been loaded.

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 v3.2.0 dated 2023-08-01 and is a stable build.

8.1 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.

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

ΔE_{sys}
W_{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 angular momentum principle. Use starred variants to get arrow notation for vectors.

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

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

8.2 Other Symbols

N 2021-02-13 **\energyof**{⟨*label*⟩}[⟨*label*⟩]

Generic symbol for the energy of some entity.

```
\( \energyof{\symup{electron}} \) \\
\( \energyof{\symup{electron}}[\symup{final}] \)
```

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

N 2021-02-13 **\systemenergy**[⟨*label*⟩]

Symbol for system energy.

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

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

N 2021-02-13 **\particleenergy**[⟨*label*⟩]

Symbol for particle energy.

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

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

N 2021-02-13 **\restenergy**[⟨*label*⟩]

Symbol for rest energy.

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

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

N 2021-02-13 `\internalenergy[⟨label⟩]`

Symbol for internal energy.

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

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

N 2021-02-13 `\chemicalenergy[⟨label⟩]`

Symbol for chemical energy.

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

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

N 2021-02-13 `\thermalenergy[⟨label⟩]`

Symbol for thermal energy.

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

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

N 2021-02-13 `\photonenergy[⟨label⟩]`

Symbol for photon energy.

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

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

N 2021-02-13 `\translationalkineticenergy[⟨label⟩]`
N 2021-02-13 `\translationalkineticenergy*[⟨label⟩]`

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

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

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

N 2021-02-13 `\rotationalkineticenergy[⟨label⟩]`
N 2021-02-13 `\rotationalkineticenergy*[⟨label⟩]`

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

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

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

N 2021-02-13 **\vibrationalkineticenergy**[⟨*label*⟩]
N 2021-02-13 **\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}
$E_{\mathrm{vib,initial}}$

N 2021-02-13 **\gravitationalpotentialenergy**[⟨*label*⟩]

Symbol for gravitational potential energy.

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

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

N 2021-02-13 **\electricpotentialenergy**[⟨*label*⟩]

Symbol for electric potential energy.

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

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

N 2021-02-13 **\springpotentialenergy**[⟨*label*⟩]

Symbol for spring potential energy.

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

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

8.3 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.

```
\def\mandiexp@version{3.2.0}
\def\mandiexp@date{2023-08-01}
\NeedsTeXFormat{LaTeX2e}[2020-02-02]
\DeclareRelease{v3.2.0}{2023-08-01}{mandiexp.sty}
\DeclareCurrentRelease{v\mandiexp@version}{\mandiexp@date}
\ProvidesPackage{mandiexp}
  [\mandiexp@date\space v\mandiexp@version\space Macros for Matter & Interactions]
```

Define a convenient package version command.

```
\newcommand*{\mandiexpversion}{v\mandiexp@version\space dated \mandiexp@date}
```

We need mandi to load mathtools and unicode-math.

```
\IfPackageLoadedTF{mandi}%
  {}%
  {%
    \RequirePackage{mandi}%
  }%
```

We need mandistudent for the new `\vec*` command.

```
\IfPackageLoadedTF{mandistudent}%
  {}%
  {%
    \RequirePackage{mandistudent}%
  }%
```

Load xparse if necessary.

```
\IfFormatAtLeastTF{2020-10-01}%
  {}%
  {\RequirePackage{xparse}}%
```

We require the LuaLaTeX engine.

```
\RequireLuaTeX
```

```
\typeout{}%
\typeout{mandiexp: You are using mandiexp \mandiexpversion.}
\typeout{mandiexp: This package requires LuaLaTeX.}%
\typeout{}%
```

The momentum principle's lefthand and righthand sides.

```
\NewDocumentCommand{\lhsmomentumprinciple}{ s }%
  {%
    \Delta
    \IfBooleanTF{#1}%
      {%
        \vec*{p}
      }%
      {%
        \vec{p}%
      }%
    \sb{\symup{sys}}%
  }%
\NewDocumentCommand{\rhsmomentumprinciple}{ s }%
  {%
    \IfBooleanTF{#1}%
```

```
      {%
        \vec*{F}%
      }%
      {%
        \vec{F}%
      }%
    \sb{\symup{sys,net}}\,\Delta t%
  }%
```

The momentum principle in update form, lefthand and righthand sides.

```
\NewDocumentCommand{\lhsmomentumprincipleupdate}{ s }%
  {%
    \IfBooleanTF{#1}%
      {%
        \vec*{p}%
      }%
      {%
        \vec{p}%
      }%
    \sb{\symup{sys,final}}%
  }%
\NewDocumentCommand{\rhsmomentumprincipleupdate}{ s }%
  {%
    \IfBooleanTF{#1}%
      {%
        \vec*{p}%
      }%
      {%
        \vec{p}%
      }%
    \sb{\symup{sys,initial}}+%
    \IfBooleanTF{#1}%
      {%
        \vec*{F}%
      }%
      {%
        \vec{F}%
      }%
    \sb{\symup{sys,net}}\,\Delta t%
  }%
```

The full momentum principle as an expression.

```
\NewDocumentCommand{\momentumprinciple}{ s }%
  {%
    \IfBooleanTF{#1}%
      {%
        \lhsmomentumprinciple* = \rhsmomentumprinciple*%
      }%
      {%
        \lhsmomentumprinciple = \rhsmomentumprinciple%
      }%
  }%
```

The full momentum principle in update form as an expression.

```
\NewDocumentCommand{\momentumprincipleupdate}{ s }%
  {%
    \IfBooleanTF{#1}%
      {%
        \lhsmomentumprincipleupdate* = \rhsmomentumprincipleupdate*%
```

```
      }%
      {%
        \lhsmomentumprincipleupdate = \rhsmomentumprincipleupdate%
      }%
  }%
```

The energy principle's lefthand and righthand sides.

```
\NewDocumentCommand{\lhsenergyprinciple}{}%
  {%
    \Delta E_{\symup{sys}}%
  }%
\NewDocumentCommand{\rhsenergyprinciple}{ O{} }%
  {%
    W_{\symup{ext}}#1%
  }%
```

The energy principle in update form, lefthand and righthand sides.

```
\NewDocumentCommand{\lhsenergyprincipleupdate}{}%
  {%
    E_{\symup{sys,final}}%
  }%
\NewDocumentCommand{\rhsenergyprincipleupdate}{ O{} }%
  {%
    E_{\symup{sys,initial}}+%
    W_{\symup{ext}}#1%
  }%
```

The full energy principle as an expression.

```
\NewDocumentCommand{\energyprinciple}{ O{} }%
  {%
    \lhsenergyprinciple = \rhsenergyprinciple[#1]%
  }%
```

The full energy principle in update form as an expression.

```
\NewDocumentCommand{\energyprincipleupdate}{ O{} }%
  {%
    \lhsenergyprincipleupdate = \rhsenergyprincipleupdate[#1]%
  }%
```

The angular momentum principle's lefthand and righthand sides.

```
\NewDocumentCommand{\lhsangularmomentumprinciple}{ s }%
  {%
    \Delta%
    \IfBooleanTF{#1}%
      {%
        \vec*{L}%
      }%
      {%
        \vec{L}%
      }%
    \sb{A\symup{,sys,net}}%
  }%
\NewDocumentCommand{\rhsangularmomentumprinciple}{ s }%
  {%
    \IfBooleanTF{#1}%
      {%
        \vec*{\tau}%
      }%
      {%
```

```
        \vec{\tau}%
      }%
    \sb{A\symup{,sys,net}}\,\Delta t%
  }%
```

The energy principle in update form, lefthand and righthand sides.

```
\NewDocumentCommand{\lhsangularmomentumprincipleupdate}{ s }%
  {%
    \IfBooleanTF{#1}%
      {%
        \vec*{L}%
      }%
      {%
        \vec{L}%
      }%
    \sb{A,\symup{sys,final}}%
  }%
\NewDocumentCommand{\rhsangularmomentumprincipleupdate}{ s }%
  {%
    \IfBooleanTF{#1}%
      {%
        \vec*{L}%
      }%
      {%
        \vec{L}%
      }%
    \sb{A\symup{,sys,initial}}+%
    \IfBooleanTF{#1}%
      {%
        \vec*{\tau}%
      }%
      {%
        \vec{\tau}%
      }%
    \sb{A\symup{,sys,net}}\,\Delta t%
  }%
```

The full angular momentum principle as an expression.

```
\NewDocumentCommand{\angularmomentumprinciple}{ s }%
  {%
    \IfBooleanTF{#1}%
      {%
        \lhsangularmomentumprinciple* = \rhsangularmomentumprinciple*%
      }%
      {%
        \lhsangularmomentumprinciple = \rhsangularmomentumprinciple%
      }%
  }%
```

The full angular momentum principle in update form as an expression.

```
\NewDocumentCommand{\angularmomentumprincipleupdate}{ s }%
  {%
    \IfBooleanTF{#1}%
      {%
        \lhsangularmomentumprincipleupdate* = \rhsangularmomentumprincipleupdate*%
      }%
      {%
        \lhsangularmomentumprincipleupdate = \rhsangularmomentumprincipleupdate%
      }%
  }%
```

The symbol for an arbitrary entity.

```
\NewDocumentCommand{\energyof}{ m o }%
  {%
    E_{#1%
        \IfValueT{#2}%
          {,#2}%
      }%
  }%
```

The symbol for a system's energy.

```
\NewDocumentCommand{\systemenergy}{ o }%
  {%
    E_{\symup{sys}%
        \IfValueT{#1}%
          {,#1}%
      }%
  }%
\NewDocumentCommand{\particleenergy}{ o }%
  {%
    E_{\symup{particle}%
        \IfValueT{#1}%
          {,#1}%
      }%
  }%
```

The symbol for a particle's rest energy.

```
\NewDocumentCommand{\restenergy}{ o }%
  {%
    E_{\symup{rest}%
        \IfValueT{#1}%
          {,#1}%
      }%
  }%
```

The symbol for a system's internal energy.

```
\NewDocumentCommand{\internalenergy}{ o }%
  {%
    E_{\symup{internal}%
        \IfValueT{#1}%
          {,#1}%
      }%
  }%
```

The symbol for a system's chemical energy.

```
\NewDocumentCommand{\chemicalenergy}{ o }%
  {%
    E_{\symup{chem}%
        \IfValueT{#1}%
          {,#1}%
      }%
  }%
```

The symbol for a system's thermal energy.

```
\NewDocumentCommand{\thermalenergy}{ o }%
  {%
    E_{\symup{therm}%
        \IfValueT{#1}%
          {,#1}%
      }%
  }%
```

The symbol for a photon's energy.

```
\NewDocumentCommand{\photonenergy}{ o }%
  {%
    E_{\symup{photon}%
        \IfValueT{#1}%
          {,#1}%
      }%
  }%
```

The symbol for translational kinetic energy. `d[]` must be used because of the way consecutive optional arguments are handled. See xparse docs for details.
See https://tex.stackexchange.com/a/569011/218142.

```
\NewDocumentCommand{\translationalkineticenergy}{ s d[] }%
  {%
    \IfBooleanTF{#1}%
      {%
        E_\bgroup \symup{K}%
      }%
      {%
        K_\bgroup\symup{trans}%
      }%
            \IfValueT{#2}{,#2}%
          \egroup%
  }%
```

The symbol for rotational kinetic energy.

```
\NewDocumentCommand{\rotationalkineticenergy}{ s d[] }%
  {%
    \IfBooleanTF{#1}%
      {%
        E_\bgroup%
      }%
      {%
        K_\bgroup%
      }%
            \symup{rot}\IfValueT{#2}{,#2}%
          \egroup%
  }%
```

The symbol for vibrational kinetic energy.

```
\NewDocumentCommand{\vibrationalkineticenergy}{ s d[] }%
  {%
    \IfBooleanTF{#1}%
      {%
        E_\bgroup%
      }%
      {%
        K_\bgroup%
      }%
            \symup{vib}\IfValueT{#2}{,#2}%
          \egroup%
  }%
```

The symbol for a system's gravitational potential energy.

```
\NewDocumentCommand{\gravitationalpotentialenergy}{ o }%
  {%
    U_{\symup{g}%
        \IfValueT{#1}%
```

```
          {,#1}%
    }%
  }%
```

The symbol for a system's electric potential energy.

```
\NewDocumentCommand{\electricpotentialenergy}{ o }%
  {%
    U_{\symup{e}%
        \IfValueT{#1}%
          {,#1}%
      }%
  }%
```

The symbol for a system's spring potential energy.

```
\NewDocumentCommand{\springpotentialenergy}{ o }%
  {%
    U_{\symup{s}%
        \IfValueT{#1}%
          {,#1}%
      }%
  }%
```

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