# Description of PhysNote.tex

A LaTeX "style file"

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## Contents

# 1 Purpose and Usage

Basically, the "style file" `PhysNote.tex` is ideal for writing physics notes when using LaTeX. See the *Features* and *Defined Macros* sections to verify this claim for yourself. (`PhysNote.tex` was used in the creation of this very document, by the way.) To use `PhysNote.tex`, first you must save it in a particular location in your computer, as described in the next section, *File Placement: The texmf Tree.* Then just put `\include{PhysNote}` in your preamble (between `\documentclass...` and `\begin{document}`) and then start using its features and functions (or macros). See below for an example of how this might look in a file.

(See the *Features* section for details on the redefinition of `\maketitle` and the addition of `\subtitle`, and see the *Package Suggestions and Elaborations* section for more on `srcltx`.)

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```
% filename: ElectrodynamicsNotes.tex
\documentclass[11pt,letterpaper]{article}
\include{PhysNote}
\usepackage{srcltx} % for those of you using Unix-based systems

\title{Electrodynamics in a Nutshell}
\subtitle{From Static Cling and Lodestones to Electroweak Unification}
\author{Your Name Here}
\date{}

\begin{document}
\maketitle
\tableofcontents

\section{In The Beginning}
\textit{Et cetera}\ldots

\end{document}
```

---

# 2 File Placement: The texmf Tree

I'll try to explain this concisely sometime, but for now you'll just have to read the information at
SourceForge.net [4] `http://sourceforge.net/docman/display_doc.php?docid=19464&group_id=92412`
or CTAN.org [5] `http://www.ctan.org/installationadvice/` for full details and use my example below as a reference. The SourceForge article describes where to save a class or package so that TeX (or LaTeX) can find it; treat `PhysNote.tex` in the same manner, even though it's not a class or package. The CTAN article gives more detail and examples.

My example: At the moment, I'm using Kubuntu GNU/Linux, and so I've saved my copy of `PhysNote.tex` at `texmf/tex/latex/physnote/` in my user home directory. (So the full path to the file is `/home/myusername/texmf/tex/latex/physnote/PhysNote.tex`.)

# 3 Features

- (Eventually, I'd like to use the same kind of fonts that, say, Sean Carrol uses in his GR book. Compare his $x$'s, $\lambda$'s, and $\tau$'s with these, in particular.)
- Reduces the top and side page margins to 0.75in and the bottom page margin to 0.5in for more space.
- Redefines `\maketitle` to save space, with the addition of the `\subtitle{}` variable. `\maketitle` is made versatile by allowing you to leave out various variables (including `\title{}`, `\subtitle{}`, `\author{}`, or `\date{}`) while still forcing everything to be centered. Write `\date{}` (with no argument) to get rid of the date.

  *Note*: If you start your document with `\maketitle`, but without a section title (i.e., you don't use `\section{}`), your text will overlap with your title section. (The `\maketitle` code was optimized for documents with titles and section headings.) You'll have to add your own space either by starting your document with an empty, unnumbered section heading (`\section*{}` with nothing in the braces), or by manually inserting space with `\vspace{20pt}` (or some other amount), or by inserting `\indent`.

- The following feature doesn't seem to work (as advertized in commath): Nested braces are made to grow (`\delimitershortfall-1sp`): $((x)(y))$

$$((x)(y)FF) = \{\{x\}\{y\}FF\} = [[x][y]FF]$$

# 4 Packages Included

- `ifthen` allows the use of "if", "then", and "else" statements (`\ifthenelse{}{}{}`) in defining macros.
- `geometry` sets margins and page size. (Options chosen: `dvips`, `pdftex`, `hmargin=0.75in`, `top=0.75in`, `bottom=0.5in`, `footskip=0.5in`, `includefoot`)
- `multicol` allows for multiple columns in array or tabular environments.
- `graphicx` allows for eps images.
- `amsmath` is the AMS Math Package. (Does `\mathcal{}` come from `amsmath` or `amssymb`? Should we use the Euler `\mathcal{}` instead of the one that yeilds $\mathcal{M}$?)
- `amsthm` provides theorem formatting.
- `amssymb` provides math macros such as `\boldsymbol{}` to augment `\mathbf{}`.
- `mathrsfs` provides script letters (rsfs: Ralph Smith Formal Script) for Lagrangian densities, etc. `\mathscr{L}` yeilds $\mathscr{L}$
- `verbatim` allows you to display almost any sequence of symbols, printed in `typewriter font`, using `\verb`.
- `url` is the same as verbatim but allows line breaks and spaces, using `\url{}`. (Options chosen: obeyspaces, spaces)
- `accents` allows stacking of accents (and "faked" accents like $\star$) and under-accenting, along with shifting accents to match letter slanting. (See more below in the *Package Suggestions and Elaborations* section.)

$$\overset{\star}{\hat{\tilde{\mathring{\phi}}}} \qquad \utilde{n} = n_{\mathrm{r}} + in_{\mathrm{i}}$$

- `tensind` fixes tensor index positioning and makes tensor code more compact. (`\tensordelimiter` is set to `?`, so question marks are used as tensor delimiters in math mode. If you want to put a question mark in an equation, you can put `\t{?}` in the equation; `\t{}` is a macro that is described in the *Defined Macros* section below. See more below in the *Package Suggestions and Elaborations* section.)
- `SIunits` standardizes quantity and SI unit spacing. (Options chosen: noams, squaren, and Gray.) `\unit{2.00}{\centi\meter}` yeilds

2.00 cm

- `cancel` allows crossing out of text or mathematical terms and arrows pointing to values taken in math mode: using `\cancel{}`, `\bcancel{}`, and `\xcancel{}`, words can be ~~crawsed~~ ~~crozzed~~ ~~krossed~~ crossed out and so can math terms, but in addition math terms can cancel to (`\cancelto{}{}`) something:

$$\cancelto{5}{2+3}$$

- `ulem` provides single, double, and wavy underlining, ~~strike-out~~, and ~~wash out~~. (See more below in the *Package Suggestions and Elaborations* section.)
- (Some macros from the `commath` package were appropriated.)

# 5 Defined Macros

What is a macro? A macro in LaTeX is basically a function: a word or string of characters that is a substitute for a longer bit of code that performs some typographic function and that may take some arguments to determine or modify that function. (The longer bits of code are contained in `PhysNote.tex`, inside the definitions of each macro.) All of the defined macros are listed below, arranged by topic. (An overview is included at the end of this document.)

### 5.1 Subtitle Feature

- `\subtitle{}` is defined. (See the *Features* section above for an explanation along with `\maketitle`.)

### 5.2 Scientific Notation and Units

- `\sn{}{}` allows you to quickly and uniformly write numbers in scientific notation, without units. `\sn{2.9979}{8}` yeilds $2.9979\times10^{8}$.

$$2.9979\times10^{8}$$

- `\snu{}{}{}` allows you to write numbers in scientific notation, with units, uniformly. (Refer to the SIunits package literature to learn how to write units.) `\snu{2.9979}{8}{\meter\per\second}` yields $2.9979\times10^{8}$ m/s.

$$2.9979\times10^{8}\ \mathrm{m/s}$$

  Simply writing `$2.9979\times10^8$ m/s` would yield $2.9979\times10^{8}$ m/s, but it is beneficial to have clear, clean code that is uniform and that you can alter simply by changing the macro definition.

  - To write a number with units that's not in scientific notation, use the `\unit{}{}` macro provided by SIunits: `\unit{1.21}{\giga\watt}` yields 1.21 GW.

### 5.3 Points, Vectors, Coordinates, Operators, and Transforms

- `\c{}` puts a tilde under characters (see also `\cv{}` below) to indicate that they represent complex numbers (or, if you will, points in complex space):

$$\underset{\sim}{n}(\omega) = \sqrt{\mu_r\, \underset{\sim}{\varepsilon}_r(\omega)}$$

- `\ft{}` puts a tilde over characters (see also `\ftv{}` below) to indicate that they are the Fourier transform of the original characters. In unitary form, we have

$$\rho(\mathbf{x},t) = \frac{1}{\sqrt{2\pi}}\int_{-\infty}^{\infty} \mathrm{d}\omega\, \tilde{\rho}(\mathbf{x},\omega)\, e^{-i\omega t} \qquad \tilde{\rho}(\mathbf{x},t) = \frac{1}{\sqrt{2\pi}}\int_{-\infty}^{\infty} \mathrm{d}t\, \rho(\mathbf{x},\omega)\, e^{i\omega t}$$

- `\pt{}` creates bold (script) text for points in a mathematical space (e.g., a manifold) such as $\boldsymbol{x}$. (It can be useful to distinguish between points $\boldsymbol{x}$ and vectors $\mathbf{x}$ at times; the coordinates of points and the components of vectors may have different transformation properties, for example.)

- `\v{}` creates bold text for vectors such as $\mathbf{v}$ and vector fields such as $\mathbf{F}(\mathbf{r})$ or $\mathbf{F}(\boldsymbol{x})$, etc. (We rename the existing command `\v{}` as `\vaccent{}`, so `\vaccent{a}` yields ǎ.)

- `\gv{}` allows vectors of Greek letters ($\boldsymbol{\theta}$, $\boldsymbol{\phi}$, $\boldsymbol{\mu}$, $\boldsymbol{\xi}$, etc.) and of other symbols ($\boldsymbol{\nabla}$). (Returns $\boldsymbol{n}$, $\boldsymbol{v}$, etc. for Latin/Roman/English letters.)

- `\uv{}` makes bold text with a circumflex for unit vectors such as $\hat{\mathbf{n}}$. Note that, normally, the circumflex or caret or "hat" is printed with normal weight in unit vector notation, instead of in bold; but that convention causes problems with the greek unit vectors (see next item), so I've defied the convention to make all my unit vector notation consistent. (This defiance allows for an advantage for `\vo{}` below.)

- `\guv{}` allows for Greek unit vectors such as $\hat{\boldsymbol{\theta}}$, $\hat{\boldsymbol{\phi}}$, $\hat{\boldsymbol{\mu}}$, and $\hat{\boldsymbol{\xi}}$. (Returns $\hat{\boldsymbol{n}}$, $\hat{\boldsymbol{v}}$, etc. for Latin/Roman/ English letters.) (Note that if we had left the caret or circumflex or "hat" with normal weight, as is usually done with unit vector notation, instead of making it bold, then it would not be well-centered over some of these symbols, such as $\phi$: $\hat{\boldsymbol{\phi}}$.)

$$\hat{\boldsymbol{\Gamma}}\hat{\boldsymbol{\Delta}}\hat{\boldsymbol{\Theta}}\hat{\boldsymbol{\Lambda}}\hat{\boldsymbol{\Xi}}\hat{\boldsymbol{\Pi}}\hat{\boldsymbol{\Sigma}}\hat{\boldsymbol{\Upsilon}}\hat{\boldsymbol{\Phi}}\hat{\boldsymbol{\Psi}}\hat{\boldsymbol{\Omega}}\hat{\boldsymbol{\alpha}}\hat{\boldsymbol{\beta}}\hat{\boldsymbol{\gamma}}\hat{\boldsymbol{\delta}}\hat{\boldsymbol{\epsilon}}\hat{\boldsymbol{\zeta}}\hat{\boldsymbol{\eta}}\hat{\boldsymbol{\theta}}\hat{\boldsymbol{\iota}}\hat{\boldsymbol{\kappa}}\hat{\boldsymbol{\lambda}}\hat{\boldsymbol{\mu}}\hat{\boldsymbol{\nu}}\hat{\boldsymbol{\xi}}\hat{\boldsymbol{\pi}}\hat{\boldsymbol{\rho}}\hat{\boldsymbol{\sigma}}\hat{\boldsymbol{\tau}}\hat{\boldsymbol{\upsilon}}\hat{\boldsymbol{\phi}}\hat{\boldsymbol{\chi}}\hat{\boldsymbol{\psi}}\hat{\boldsymbol{\omega}}$$

  I would use `upgreek` (package) characters to follow the convention of upright letters for vectors, but they don't look as good (in particular ϕ) and seem out of place next to the usual greek letters ($\alpha, \beta, \gamma$, etc.):

$$\hat{\upalpha}\hat{\upbeta}\hat{\upgamma}\hat{\updelta}\hat{\upepsilon}\hat{\upzeta}\hat{\upeta}\hat{\uptheta}\hat{\upiota}\hat{\upkappa}\hat{\uplambda}\hat{\upmu}\hat{\upnu}\hat{\upxi}\hat{\uppi}\hat{\uprho}\hat{\upsigma}\hat{\uptau}\hat{\upupsilon}\hat{\upphi}\hat{\upchi}\hat{\uppsi}\hat{\upomega}$$

- \op{} produces notation for an operator: \op{J} yields $\hat{J}$. (This is just a shorthand for \hat{}. It can be useful in code to distinguish between different uses of \hat{}: for example, one meaning might be for operators and another might be to indicate coordinates from a particular coordinate system.)

- \vo{} produces notation for a vector operator: \vo{J} yields $\hat{\mathbf{J}}$. Since I have defied the usual unit vector notation, this is subtly different from my unit vector notation since the circumflex is not bold. This is satisfying: the bold circumflex indicates a unit vector, the normal-weight circumflex indicates an operator.

$$\hat{\mathbf{J}} \neq \hat{\mathbf{J}}$$

- \co{} produces notation for a complex operator: \co{\pi} yields $\hat{\underset{\sim}{\pi}}$.

$$\hat{\underset{\sim}{\pi}} \neq \hat{\underset{\sim}{\boldsymbol{\pi}}}$$

- \gvo{} produces notation for a greek vector operator: \gvo{\mu} yields $\hat{\boldsymbol{\mu}}$.

$$\hat{\boldsymbol{\mu}} = -\frac{\mu_{\mathrm{B}}}{\hbar}(\hat{\mathbf{L}} + g\hat{\mathbf{S}})$$

- \cv{} produces notation for a complex vector: \cv{v} yields $\underset{\sim}{\mathbf{v}}$. If $\underset{\sim}{\mathbf{v}} = \mathbf{v}_{\mathrm{r}} + i\mathbf{v}_{\mathrm{i}}$, then

$$\underset{\sim}{\mathbf{v}}^2 = \underset{\sim}{\mathbf{v}} \cdot \underset{\sim}{\mathbf{v}} = \left(\mathbf{v}_{\mathrm{r}}{}^2 - \mathbf{v}_{\mathrm{i}}{}^2\right) + i\left(2\mathbf{v}_{\mathrm{r}} \cdot \mathbf{v}_{\mathrm{i}}\right) \neq \|\underset{\sim}{\mathbf{v}}\|^2 = \left|\underset{\sim}{\mathbf{v}}^2\right|$$

- \ftc{} produces notation for the Fourier transform of a complex function: \ftc{f} yields $\tilde{\underset{\sim}{f}}$.

$$\tilde{\underset{\sim}{f}}(\omega) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\infty} \mathrm{d}t \; \underset{\sim}{f}(t)\, e^{-i\omega t}$$

- \ftv{} produces notation for the Fourier transform of a vector function: \ftv{v} yields $\tilde{\mathbf{v}}$.

$$\tilde{\mathbf{E}}(\mathbf{x}, \omega) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\infty} \mathrm{d}t \; \mathbf{E}(\mathbf{x}, t)\, e^{-i\omega t}$$

- \ftcv{} produces notation for the Fourier transform of a complex vector function: \ftcv{v} yields $\tilde{\underset{\sim}{\mathbf{v}}}$.

$$\tilde{\underset{\sim}{\mathbf{E}}}(\mathbf{x}, \omega) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\infty} \mathrm{d}t \; \underset{\sim}{\mathbf{E}}(\mathbf{x}, t)\, e^{-i\omega t}$$

- \fv{} produces notation for a four-vector (or 4-vector): \fv{p} yields $\underline{p}$.

$$\underline{p} = p^{\mu}\underline{e}_{\mu} = p^0\underline{e}_0 + p^1\underline{e}_1 + p^2\underline{e}_2 + p^3\underline{e}_3$$

$$\underline{a} \cdot \underline{p} = a^{\mu}p_{\mu} = -a^0p^0 + a^1p^1 + a^2p^2 + a^3p^3$$

- \acoord{} (\acoord[0]{}) produces (horizontal) notation for a point in some arbitrary dimensional space: \acoord{x,y} yields $(x, y)$. The optional argument [0] forces the parentheses to be their normal text size.

$$\left(v^A, w^B, x^C, y^D, z^E\right) = (v^A, w^B, x^C, y^D, z^E)$$

- \avector{} (\avector[0]{}) produces (horizontal) notation for a vector in some arbitrary dimensional vector space: \avector{x,y} yields $\langle x, y\rangle$. The optional argument [0] forces the parentheses to be their normal text size.

$$\left\langle v^A, w^B, x^C, y^D, z^E\right\rangle = \langle v^A, w^B, x^C, y^D, z^E\rangle$$

- \tcoord{}{}{} produces (horizontal) notation for a point in some (t)hree-coordinate space:
\tcoord{x}{y}{z} yields $(x, y, z)$. $\left(A^B, y, z\right)$

$$\left(A^B, y, z\right)$$

- `\vtcoord{}{}{}` produces vertical notation for a point in some (t)hree-coordinate space: `\vtcoord{A^B}{y}{z}` yields

$$\begin{pmatrix} A^B \\ y \\ z \end{pmatrix}$$

- `\dcoord{}{}{}` produces notation for a point in (De)cartesian coordinate space: `\dcoord{x}{y}{z}` yields $(x, y, z)_\mathrm{d}$. $\left(A^B, y, z\right)_\mathrm{d}$

$$\left(A^B, y, z\right)_\mathrm{d}$$

- `\ccoord{}{}{}` produces notation for a point in cylindrical coordinate space: `\ccoord{s}{\phi}{z}` yields $(s, \phi, z)_\mathrm{c}$. $\left(C^D, \phi, z\right)_\mathrm{c}$

$$\left(C^D, \phi, z\right)_\mathrm{c}$$

- `\scoord{}{}{}` produces notation for a point in spherical coordinate space: `\scoord{r}{\theta}{\phi}` yields $(r, \theta, \phi)_\mathrm{s}$. $\left(E^F, \theta, \phi\right)_\mathrm{s}$

$$\left(E^F, \theta, \phi\right)_\mathrm{s}$$

- `\tvector{}{}{}` produces (horizontal) notation for a (t)hree-vector in some 3-D vector space: `\tvector{a}{b}{c}` yields $\langle a, b, c\rangle$. $\left\langle A^B, V_y, V_z\right\rangle$

$$\left\langle A^B, V_y, V_z\right\rangle$$

- `\vtvector{}{}{}` produces vertical notation for a (t)hree-vector in some 3-D vector space: `\vtvector{V_x}{V_y}{V_z}` yields

$$\left\langle \begin{matrix} V_x \\ V_y \\ V_z \end{matrix} \right\rangle$$

- `\dvector{}{}{}` produces notation for a vector in (De)cartesian coordinate space: `\dvector{a}{b}{c}` yields $\langle a, b, c\rangle_\mathrm{d}$. $\left\langle A^B, V_y, V_z\right\rangle_\mathrm{d}$

$$\left\langle A^B, V_y, V_z\right\rangle_\mathrm{d}$$

- `\cvector{}{}{}` produces notation for a vector in cylindrical coordinate space: `\cvector{a}{b}{c}` yields $\langle a, b, c\rangle_\mathrm{c}$. $\left\langle C^D, V_\phi, V_z\right\rangle_\mathrm{c}$

$$\left\langle C^D, V_\phi, V_z\right\rangle_\mathrm{c}$$

- `\svector{}{}{}` produces notation for a vector in spherical coordinate space: `\svector{a}{b}{c}` yields $\langle a, b, c\rangle_\mathrm{s}$. $\left\langle E^F, V_\theta, V_\phi\right\rangle_\mathrm{s}$

$$\left\langle E^F, V_\theta, V_\phi\right\rangle_\mathrm{s}$$

- `\fcoord{}{}{}{}` produces (horizontal) notation for a point in some (f)our-coordinate space: `\fcoord{w}{x}{y}{z}` yields $(w, x, y, z)$. $\left(A^B, x, y, z\right)$

$$\left(A^B, x, y, z\right)$$

- `\vfcoord{}{}{}{}` produces vertical notation for a point in some (f)our-coordinate space: `\vfcoord{A^B}{x}{y}{z}` yields

$$\begin{pmatrix} A^B \\ x \\ y \\ z \end{pmatrix}$$

- `\fvector{}{}{}{}` produces (horizontal) notation for a (f)our-vector in some 4-D vector space: `\fvector{a}{b}{c}{d}` yields $\langle a, b, c, d \rangle$. $\left\langle A^B, V_x, V_y, V_z \right\rangle$

$$\left\langle A^B, V_x, V_y, V_z \right\rangle$$

- `\vfvector{}{}{}` produces vertical notation for a (f)our-vector in some 4-D vector space: `\vfvector{A^B}{V_x}{V_y}{V_z}` yields

$$\left\langle \begin{matrix} A^B \\ V_x \\ V_y \\ V_z \end{matrix} \right\rangle$$

## 5.4 Inner Product, Norm, Absolute Value, and Average

- `\ip{}{}` (`\ip[]{}{}`) produces notation for an inner product (or scalar product), with an optional argument [0] for small brackets: `\ip{\uv{X}}{\uv{Y}}` produces $\left\langle \hat{\mathbf{X}}, \hat{\mathbf{Y}} \right\rangle$ and `\ip[0]{\uv{X}}{\uv{Y}}` produces $\langle \hat{\mathbf{X}}, \hat{\mathbf{Y}} \rangle$.

$$\left\langle \hat{\mathbf{X}}, \hat{\mathbf{Y}} \right\rangle = \left\| \hat{\mathbf{X}} \right\| \left\| \hat{\mathbf{Y}} \right\| \cos\theta_{xy} = \langle \hat{\mathbf{X}}, \hat{\mathbf{Y}} \rangle = \| \hat{\mathbf{X}} \| \| \hat{\mathbf{Y}} \| \cos\theta_{xy}$$

- `\norm{}` (`\norm[]{}`) produces the norm notation, with an optional argument [0] for small bars: `\norm{\uv{X}}` produces $\left\| \hat{\mathbf{X}} \right\|$ while `\norm[0]{\uv{X}}` produces $\| \hat{\mathbf{X}} \|$.

- `\abs{}` (`\abs[]{}`) puts text in the absolute value bars ($\left| 3 \cdot 2^2 - 6^2 \right| = |12 - 36| = |-24| = 24$), with an optional argument [0] for small bars ($\left| -5^5 \right| = |-5^5| = |5^5|$).

- `\avg{}` (`\avg[]{}`) puts text in the "average brackets" or the "expectation value brackets", with an optional argument [0] for small brackets: `\avg{X^{Y^Z}}` produces $\left\langle X^{Y^Z} \right\rangle$ and `\avg[0]{X^{Y^Z}}` produces $\langle X^{Y^Z} \rangle$. (Note: for clarity, one might add some form of subscript to indicate what kind of averaging or "expecting" is being done. For instance, a time averaging of a function $f$ could be denoted by $\langle f \rangle_t$ with `\avg{f}_t`, or the expectation value of a quantity $A$ for a particular state vector $|\phi\rangle$ could be denoted by $\langle A \rangle_{|\phi\rangle}$ with `\avg{A}_{\ket{\phi}}`. ...See `\ket{}` below.)

## 5.5 Differentials

- `\d` gives a differential operator or shorthand for a derivative (when used with a subscript): $\mathrm{d}x$ or $\mathrm{d}_t f = \frac{\mathrm{d}f}{\mathrm{d}t}$.

$$\mathrm{d}x$$

$$\int_{\mathbb{R}^3} \mathrm{d}^3x \ f(\mathbf{x})$$

(We rename the existing command `\d{}` as `\underdot{}`, so `\underdot{a}` yields ạ.)

- `\dbar` gives the symbol for "inexact" differentials: đ, as in an infinitesimal amount of work đ$W$.

- `\D` gives a general notation for some derivative operator: $\mathrm{D}F$

$$a_3 \mathrm{D}^3 f + a_2 \mathrm{D}^2 f + a_1 \mathrm{D} f + a_0 = 0$$

- `\fD` gives the functional differential operator $\mathcal{D}$:

$$\int \mathcal{D}\phi \ \rho[\phi] = 1$$

- `\p` replaces `\partial` for convenience, to produce the partial differential or a partial derivative. Using a subscript yeilds a shorthand notation for a partial derivative where the subscript indicates what variable the derivative is respecting: $\partial_t f = \frac{\partial f}{\partial t}$. This macro is also for ease in writing the "vector derivative" $\partial_\mu$ and the "covector derivative" $\partial^\mu$ in relativity.

$$\Box\phi = \partial^2\phi = \partial_\mu\partial^\mu\phi = \left( c^2 {\partial_t}^2 - \nabla^2 \right) \phi$$

### 5.6 Derivatives

- `\od{}{}` (`\od[]{}{}`) gives an ordinary derivative of the first argument with respect to the second argument. The optional argument (in square brackets, if you insert it), gives the order of the derivative. `\od{f}{x}` yields $\frac{\mathrm{d}f}{\mathrm{d}x}$ and `\od[n]{f}{x}` yields $\frac{\mathrm{d}^n f}{\mathrm{d}x^n}$. Similarly, we have $\frac{\mathrm{d}y}{\mathrm{d}x}$, $\frac{\mathrm{d}x}{\mathrm{d}x}$, and $\frac{\mathrm{d}d}{\mathrm{d}x}$. Also, superscripts and subscripts are handled: `\od[2]{f}{x_i}` yields $\frac{\mathrm{d}^2 f}{\mathrm{d}{x_i}^2}$ and `\od[2]{f}{x^i}` yields $\frac{\mathrm{d}^2 f}{\mathrm{d}{x^i}^2}$.

$$\frac{\mathrm{d}^n f}{\mathrm{d}x^n} = \frac{\mathrm{d}}{\mathrm{d}x}\frac{\mathrm{d}^{n-1} f}{\mathrm{d}x^{n-1}}$$

  - `\tod{}{}` (`\tod[]{}{}`) is the same as `\od{}{}` except that it is always in text math mode: $\tfrac{\mathrm{d}f}{\mathrm{d}x} = \tfrac{\mathrm{d}^1 f}{\mathrm{d}x^1}$.

$$\tfrac{\mathrm{d}f}{\mathrm{d}x} = \tfrac{\mathrm{d}^1 f}{\mathrm{d}x^1}$$

  - `\dod{}{}` (`\dod[]{}{}`) is the same as `\od{}{}` except that it is always in display math mode: $\dfrac{\mathrm{d}f}{\mathrm{d}x} = \dfrac{\mathrm{d}^1 f}{\mathrm{d}x^1}$.

$$\frac{\mathrm{d}f}{\mathrm{d}x} = \frac{\mathrm{d}^1 f}{\mathrm{d}x^1}$$

  - `\sod{}{}` (`\sod[]{}{}`) is the same as `\od{}{}` except that it is always in what I'll call "slash" or "slant" mode: $\mathrm{d}f/\mathrm{d}x = \mathrm{d}^1 f/\mathrm{d}x^1$.

$$\mathrm{d}f/\mathrm{d}x = \mathrm{d}^1 f/\mathrm{d}x^1$$

- `\pd{}{}` (`\pd[]{}{}`) is the same as `\od{}{}` except that it gives a partial derivative. `\pd{f}{x}` yields $\frac{\partial f}{\partial x}$ and `\pd[n]{f}{x}` yields $\frac{\partial^n f}{\partial x^n}$.

$$\frac{\partial^n f}{\partial x^n} = \frac{\partial}{\partial x}\frac{\partial^{n-1} f}{\partial x^{n-1}}$$

  - `\tpd{}{}` (`\tpd[]{}{}`) is the same as `\pd{}{}` except that it is always in text math mode: $\tfrac{\partial f}{\partial x} = \tfrac{\partial^1 f}{\partial x^1}$.

$$\tfrac{\partial f}{\partial x} = \tfrac{\partial^1 f}{\partial x^1}$$

  - `\dpd{}{}` (`\dpd[]{}{}`) is the same as `\pd{}{}` except that it is always in display math mode: $\dfrac{\partial f}{\partial x} = \dfrac{\partial^1 f}{\partial x^1}$.

$$\frac{\partial f}{\partial x} = \frac{\partial^1 f}{\partial x^1}$$

  - `\spd{}{}` (`\spd[]{}{}`) is the same as `\pd{}{}` except that it is always in "slash" mode: $\partial f/\partial x = \partial^1 f/\partial x^1$.

$$\partial f/\partial x = \partial^1 f/\partial x^1$$

- `\pdc{}{}{}` gives a partial derivative that explicitly names the variable(s) being held constant. (This is often used in thermodynamics.) `\pdc{f}{x}{y}` yields $\left(\frac{\partial f}{\partial x}\right)_y$.

$$\left(\frac{\partial U}{\partial S}\right)_{V,N,\ldots} = T$$

$$\left(\frac{\partial U}{\partial S}\right)_V abc = \left(\frac{\partial U}{\partial S}\right)_V \text{(55)}$$

– `\tpdc{}{}{}` (`\tpdc[]{}{}{}`) is the same as `\pdc{}{}{}` except that it is always in text math mode: $\left(\tfrac{\partial f}{\partial x}\right)_y = \left(\tfrac{\partial^1 f}{\partial x^1}\right)_y$.

$$\left(\tfrac{\partial f}{\partial x}\right)_y = \left(\tfrac{\partial^1 f}{\partial x^1}\right)_y$$

$$\left(\tfrac{\partial F}{\partial X}\right)_Y abc = \left(\tfrac{\partial^1 F}{\partial X^1}\right)_Y (55)$$

– `\dpdc{}{}{}` (`\dpdc[]{}{}{}`) is the same as `\pdc{}{}{}` except that it is always in display math mode: $\left(\dfrac{\partial f}{\partial x}\right)_y = \left(\dfrac{\partial^1 f}{\partial x^1}\right)_y$.

$$\left(\frac{\partial f}{\partial x}\right)_y = \left(\frac{\partial^1 f}{\partial x^1}\right)_y$$

$$\left(\frac{\partial F}{\partial X}\right)_Y abc = \left(\frac{\partial^1 F}{\partial X^1}\right)_Y (55)$$

– `\spdc{}{}{}` (`\spdc[]{}{}{}`) is the same as `\pdc{}{}{}` except that it is always in "slash" mode: $(\partial f/\partial x)_y = (\partial^1 f/\partial x^1)_y$.

$$(\partial f/\partial x)_y = (\partial^1 f/\partial x^1)_y$$

- `\md{}{}{}{}{}{}` gives a mixed (partial) derivative with respect to two variables:
  `\md{5}{f}{x}{2}{y}{3}` yields $\frac{\partial^5 f}{\partial x^2\,\partial y^3}$ and `\md{2}{f}{x}{}{y}{}` yields $\frac{\partial^2 f}{\partial x\,\partial y}$.

$$\frac{\partial^2 f}{\partial x\,\partial y} = \frac{\partial^2 f}{\partial y^1\,\partial x^1}$$

– `\tmd{}{}{}{}{}{}` is the same as `\md{}{}{}{}{}{}` except that it is always in text math mode: $\tfrac{\partial^2 f}{\partial x\,\partial y} = \tfrac{\partial^2 f}{\partial x^1\,\partial y^1}$.

$$\tfrac{\partial^2 f}{\partial x\,\partial y} = \tfrac{\partial^2 f}{\partial x^1\,\partial y^1}$$

– `\dmd{}{}{}{}{}{}` is the same as `\md{}{}{}{}{}{}` except that it is always in display math mode: $\dfrac{\partial^2 f}{\partial x\,\partial y} = \dfrac{\partial^2 f}{\partial x^1\,\partial y^1}$.

$$\frac{\partial^2 f}{\partial x\,\partial y} = \frac{\partial^2 f}{\partial x^1\,\partial y^1}$$

– `\smd{}{}{}{}{}{}` is the same as `\md{}{}{}{}{}{}` except that it is always in "slash" mode: $\partial^2 f/\partial x\,\partial y = \partial^2 f/\partial x^1\,\partial y^1$.

$$\partial^2 f/\partial x\,\partial y = \partial^2 f/\partial x^1\,\partial y^1$$

- `\dd{}{}{}` (`\dd[]{}{}{}`) gives a directional (partial) derivative. `\dd{f}{x}{n}` yields $\frac{\partial_n f}{\partial_n x}$, and
  `\dd[m]{f}{x}{n}` yields $\frac{{\partial_n}^m f}{\partial_n x^m}$.

$$\frac{\partial_n f(\mathbf{x})}{\partial_n x} \equiv \hat{\mathbf{n}}\cdot\boldsymbol{\nabla} f(\mathbf{x}) \qquad \text{aka} \quad \frac{\partial f(\mathbf{x})}{\partial n}$$

– `\tdd{}{}{}` (`\tdd[]{}{}{}`) is the same as `\dd{}{}{}` except that it is always in text math mode: $\tfrac{\partial_n f}{\partial_n x} = \tfrac{{\partial_n}^1 f}{\partial_n x^1}$.

$$\tfrac{\partial_n f}{\partial_n x} = \tfrac{{\partial_n}^1 f}{\partial_n x^1}$$

– \ddd{}{}{} (\ddd[]{}{}{}) is the same as \dd{}{}{} except that it is always in display math mode: $\dfrac{\partial_n f}{\partial_n x} = \dfrac{\partial_n{}^1 f}{\partial_n x^1}$.

$$\frac{\partial_n f}{\partial_n x} = \frac{\partial_n{}^1 f}{\partial_n x^1}$$

– \sdd{}{}{} (\sdd[]{}{}{}) is the same as \dd{}{}{} except that it is always in "slash" mode: $\partial_n f/\partial_n x = \partial_n{}^1 f/\partial_n x^1$.

$$\partial_n f/\partial_n x = \partial_n{}^1 f/\partial_n x^1$$

- \fd{}{} (\fd[]{}{}) is the same as \od{}{} and \pd{}{} except that it gives a functional derivative. \fd{F[\varphi]}{\varphi(x)} yields $\frac{\delta F[\varphi]}{\delta\varphi(x)}$ and \fd[n]{F[\varphi]}{\varphi(x)} yields $\frac{\delta^n F[\varphi]}{\delta\varphi(x)^n}$. Also, subscripts and superscripts are handled: \fd{S[\varphi]}{\varphi_i(x)} yeilds $\frac{\delta S[\varphi]}{\delta\varphi_i(x)}$ and \fd{S[\varphi]}{\varphi^i(x)} yields $\frac{\delta S[\varphi]}{\delta\varphi^i(x)}$.

$$\frac{\delta^n F[\varphi]}{\delta\varphi(x)^n} = \frac{\delta}{\delta\varphi(x)}\frac{\delta^{n-1} F[\varphi]}{\delta\varphi(x)^{n-1}}$$

– \tfd{}{} (\tfd[]{}{}) is the same as \fd{}{} except that it is always in text math mode: $\tfrac{\delta F[a]}{\delta a(x)} = \tfrac{\delta^1 F[a]}{\delta a(x)^1}$.

$$\tfrac{\delta F[a]}{\delta a(x)} = \tfrac{\delta^1 F[a]}{\delta a(x)^1}$$

– \dfd{}{} (\dfd[]{}{}) is the same as \pf{}{} except that it is always in display math mode: $\dfrac{\delta F[a]}{\delta a(x)} = \dfrac{\delta^1 F[a]}{\delta a(x)^1}$.

$$\frac{\delta F[a]}{\delta a(x)} = \frac{\delta^1 F[a]}{\delta a(x)^1}$$

– \sfd{}{} (\sfd[]{}{}) is the same as \fd{}{} except that it is always in "slash" mode: $\delta F[a]/\delta a(x) = \delta^1 F[a]/\delta a(x)^1$.

$$\delta F[a]/\delta a(x) = \delta^1 F[a]/\delta a(x)^1$$

- \mfd{}{}{}{}{}{} gives a mixed functional derivative with respect to two variables: \md{5}{F[a]}{a(x)}{2}{a(y)}{3} yields $\frac{\partial^5 F[a]}{\partial a(x)^2\,\partial a(y)^3}$ and \mfd{2}{F[a]}{a(x)}{}{a(y)}{} yields $\frac{\delta^2 F[a]}{\delta a(x)\,\delta a(y)}$.

$$\frac{\delta^2 F[a]}{\delta a(x)\,\delta a(y)} = \frac{\delta^2 F[a]}{\delta a(x)^1\,\delta a(y)^1}$$

– \tmfd{}{}{}{}{}{} is the same as \mfd{}{}{}{}{}{} except that it is always in text math mode: $\tfrac{\delta^2 F[a]}{\delta a(x)\,\delta a(y)} = \tfrac{\delta^2 F[a]}{\delta a(x)^1\,\delta a(y)^1}$.

$$\tfrac{\delta^2 F[a]}{\delta a(x)\,\delta a(y)} = \tfrac{\delta^2 F[a]}{\delta a(x)^1\,\delta a(y)^1}$$

– \dmfd{}{}{}{}{}{} is the same as \mfd{}{}{}{}{}{} except that it is always in display math mode: $\dfrac{\delta^2 F[a]}{\delta a(x)\,\delta a(y)} = \dfrac{\delta^2 F[a]}{\delta a(x)^1\,\delta a(y)^1}$.

$$\frac{\delta^2 F[a]}{\delta a(x)\,\delta a(y)} = \frac{\delta^2 F[a]}{\delta a(x)^1\,\delta a(y)^1}$$

– \smfd{}{}{}{}{}{} is the same as \mfd{}{}{}{}{}{} except that it is always in "slash" mode: $\delta^2 F[a]/\delta a(x)\,\delta a(y) = \delta^2 F[a]/\delta a(x)^1\,\delta a(y)^1$.

$$\delta^2 F[a]/\delta a(x)\,\delta a(y) = \delta^2 F[a]/\delta a(x)^1\,\delta a(y)^1$$

- \fdd{}{}{} (\fdd[]{}{}{}) gives a directional functional derivative. \fdd{F[a]}{a}{\lambda} yields $\frac{\delta_\lambda F[a]}{\delta_\lambda a}$, and \fdd[n]{F[a]}{a}{\lambda} yields $\frac{\delta_\lambda{}^n F[a]}{\delta_\lambda a^n}$.

$$\frac{\delta_\lambda F[\varphi]}{\delta_\lambda \varphi} \qquad \text{could also be known as} \qquad \frac{\delta F[a]}{\delta \lambda}$$

  - \tfdd{}{}{} (\tfdd[]{}{}{}) is the same as \fdd{}{}{} except that it is always in text math mode: $\tfrac{\delta_\lambda F[a]}{\delta_\lambda a} = \tfrac{\delta_\lambda{}^1 F[a]}{\delta_\lambda a^1}$.

$$\tfrac{\delta_\lambda F[a]}{\delta_\lambda a} = \tfrac{\delta_\lambda{}^1 F[a]}{\delta_\lambda a^1}$$

  - \dfdd{}{}{} (\dfdd[]{}{}{}) is the same as \fdd{}{}{} except that it is always in display math mode: $\dfrac{\delta_\lambda F[a]}{\delta_\lambda a} = \dfrac{\delta_\lambda{}^1 F[a]}{\delta_\lambda a^1}$.

$$\frac{\delta_\lambda F[a]}{\delta_\lambda a} = \frac{\delta_\lambda{}^1 F[a]}{\delta_\lambda a^1}$$

  - \sfdd{}{}{} (\sfdd[]{}{}{}) is the same as \fdd{}{}{} except that it is always in "slash" mode: $\delta_\lambda F[a]/\delta_\lambda a = \delta_\lambda{}^1 F[a]/\delta_\lambda a^1$.

$$\delta_\lambda F[a]/\delta_\lambda a = \delta_\lambda{}^1 F[a]/\delta_\lambda a^1$$

- \cdd{}{} (\cdd[]{}{}) is the same as \od{}{} and \pd{}{} and \fd{}{} except that it gives a "capital D derivative" or covariant directional derivative. \cdd{f}{x} yields $\frac{\mathrm{D}f}{\mathrm{d}x}$ and \cdd[n]{f}{x} yields $\frac{\mathrm{D}^n f}{\mathrm{d}x^n}$. Similarly, we have $\frac{\mathrm{D}y}{\mathrm{d}x}$, $\frac{\mathrm{D}x}{\mathrm{d}x}$, and $\frac{\mathrm{D}d}{\mathrm{d}x}$.

$$\frac{\mathrm{D}^n f}{\mathrm{d}\lambda^n} = \frac{\mathrm{D}}{\mathrm{d}\lambda} \frac{\mathrm{D}^{n-1} f}{\mathrm{d}\lambda^{n-1}}$$

  - \tcdd{}{}{} (\tcdd[]{}{}{}) is the same as \cdd{}{}{} except that it is always in text math mode: $\tfrac{\mathrm{D}f}{\mathrm{d}\lambda} = \tfrac{\mathrm{D}^1 f}{\mathrm{d}\lambda^1}$.

$$\tfrac{\mathrm{D}f}{\mathrm{d}\lambda} = \tfrac{\mathrm{D}^1 f}{\mathrm{d}\lambda^1}$$

  - \dcdd{}{}{} (\dcdd[]{}{}{}) is the same as \cdd{}{}{} except that it is always in display math mode: $\dfrac{\mathrm{D}f}{\mathrm{d}\lambda} = \dfrac{\mathrm{D}^1 f}{\mathrm{d}\lambda^1}$.

$$\frac{\mathrm{D}f}{\mathrm{d}\lambda} = \frac{\mathrm{D}^1 f}{\mathrm{d}\lambda^1}$$

  - \scdd{}{}{} (\scdd[]{}{}{}) is the same as \cdd{}{}{} except that it is always in "slash" mode: $\mathrm{D}f/\mathrm{d}\lambda = \mathrm{D}^1 f/\mathrm{d}\lambda^1$.

$$\mathrm{D}f/\mathrm{d}\lambda = \mathrm{D}^1 f/\mathrm{d}\lambda^1$$

- \grad (\grad[]) is for gradients, with an optional argument for a subscript, which can indicate the variable-space the gradient is taken with respect to: \grad produces $\boldsymbol{\nabla}$, \grad{F(\v{r})} produces $\boldsymbol{\nabla} F(\mathbf{r})$ (the braces are unnecessary), and \grad[p]F(\v{p}) produces $\boldsymbol{\nabla}_p F(\mathbf{p})$.

$$\boldsymbol{\nabla}'\left(\frac{1}{R}\right) = -\boldsymbol{\nabla}\left(\frac{1}{R}\right) = \frac{\hat{\mathbf{n}}}{R^2}$$

$$\text{where} \quad \mathbf{R} = \mathbf{r} - \mathbf{r}' \quad \text{and} \quad \hat{\mathbf{n}} \equiv \hat{\mathbf{R}}$$

- \div{} (\div[]{}) is for divergence, with an optional argument for a subscript, as there is for the gradient: \div{\v{F}(\v{r})} produces $\boldsymbol{\nabla}\cdot\mathbf{F}(\mathbf{r})$ and \div[r_2]{\v{F}(\v{r}_{12})} produces $\boldsymbol{\nabla}_{r_2}\cdot\mathbf{F}(\mathbf{r}_{12})$.

$$\boldsymbol{\nabla}_{r_2}\cdot\mathbf{F}(\mathbf{r}_{12})$$

$$\boldsymbol{\nabla}_{v}\cdot\mathbf{F}(\mathbf{r}_{12})$$

$$\boldsymbol{\nabla}_{R}\cdot\mathbf{F}(\mathbf{r}_{12})$$

$$\boldsymbol{\nabla}_{\mathbf{R}}\cdot\mathbf{F}(\mathbf{r}_{12})$$

- `\curl{}` (`\curl[]{}`) is for curl, with an optional argument for a subscript, as there is for the gradient: `\curl{\v{F}(\v{x})}` produces $\boldsymbol{\nabla}\times\mathbf{F}(\mathbf{x})$ and `\curl[p]{\v{F}(\v{p})}` produces $\boldsymbol{\nabla}_p\times\mathbf{F}(\mathbf{p})$.

$$\boldsymbol{\nabla}\times\mathbf{E} = -\partial_t\Phi_B$$

## 5.7 Dirac and Feynman Notation

- `\ket{}` (`\ket[0]{}`) is for Dirac kets: $|\phi\rangle$. The optional argument `[0]` forces the brackets to be their normal text size. For example, `\ket{\Phi^A}` and `\ket[0]{\Phi^A}` yield $\left|\Phi^A\right\rangle$ and $|\Phi^A\rangle$, and `\ket{\Phi^i}` and `\ket[0]{\Phi^i}` yield $\left|\Phi^i\right\rangle$ and $|\Phi^i\rangle$.

$$\left|\Phi^A\right\rangle = |\Phi^A\rangle$$

- `\bra{}` (`\bra[0]{}`) is for Dirac bras: $\langle\phi|$. The optional argument `[0]` functions the same as it does with the `\ket` macro.

$$\left\langle\Phi^A\right| = \langle\Phi^A|$$

- `\braket{}{}` (`\braket[0]{}{}`) is for Dirac "braket" inner products: $\langle x|\Psi\rangle$. The optional argument `[0]` functions the same as it does with the `\ket` macro.

$$\left\langle x\middle|\Psi^A\right\rangle = \langle x|\Psi^A\rangle$$

- `\ketbra{}{}` (`\ketbra[0]{}{}`) is for Dirac "ketbra" projection operators: $|\psi\rangle\langle\phi|$. The optional argument `[0]` functions the same as it does with the `\ket` macro.

$$\left|\Psi\right\rangle\left\langle\Phi^A\right| = |\Psi\rangle\langle\Phi^A|$$

- `\matrixel{}{}{}` (`\matrixel[0]{}{}{}`) is for Dirac matrix elements: $\langle\phi|\hat{\mathbf{r}}|\psi\rangle$. The optional argument `[0]` functions the same as it does with the `\ket` macro.

$$\left\langle n\middle|H^1\middle|m\right\rangle = \langle n|H^1|m\rangle$$

- `\redmatel{}{}{}` (`\redmatel[0]{}{}{}`) is for "reduced" Dirac matrix elements: $\langle\phi||\hat{\mathbf{r}}||\psi\rangle$. The optional argument `[0]` functions the same as it does with the `\ket` macro.

$$\left\langle\alpha',j',m'\middle|T^q_\kappa\middle|\alpha,j,m\right\rangle = \frac{1}{\sqrt{2j'+1}}\left\langle\phi^{j\kappa}_{j',m'}\middle|\psi^{j\kappa}_{mq}\right\rangle\left\langle\alpha',j'\middle|\middle|T_\kappa\middle|\middle|\alpha,j\right\rangle$$

$$\langle\alpha',j',m'|T^q_\kappa|\alpha,j,m\rangle = \frac{1}{\sqrt{2j'+1}}\langle\phi^{j\kappa}_{j',m'}|\psi^{j\kappa}_{mq}\rangle\langle\alpha',j'||T_\kappa||\alpha,j\rangle$$

- `\s{}` provides the Feynman slash notation: `\s{p}` yields $\not{p}$.

$$\not{a} \equiv \underline{a}\cdot\underline{\gamma} \doteq a_\mu\gamma^\mu$$

## 5.8 Trigonometrics

- `\S` is shorthand for the sine function and produces an Roman or upright letter S: $\mathrm{S}\theta \equiv \sin\theta$.

$$\mathrm{S}^2\theta = (\mathrm{S}\theta)^2 = \sin^2\theta = (\sin\theta)^2$$

(We rename the existing section symbol command `\S` as `\SS`, so `\SS` yields §.)

- `\C` is shorthand for the cosine function and produces an upright or upright letter C: $\mathrm{C}\theta \equiv \cos\theta$.

$$\mathrm{C}^2\theta = (\mathrm{C}\theta)^2 = \cos^2\theta = (\cos\theta)^2$$

- `\T` is shorthand for the tangent function and produces an upright or upright letter T: $\mathrm{T}\theta \equiv \tan\theta$.

$$\mathrm{T}^2\theta = \left(\frac{\mathrm{S}\theta}{\mathrm{C}\theta}\right)^2$$

- `\Asint{}{}` gives a two-argument arc sine (inverse sine) that returns angles in the codomain $[0, 2\pi)$:

$$\mathrm{Arcsin2}\,(y,h) = \begin{cases} \arcsin(y/h), \text{ for } h \geq 0 \text{ and } y \geq 0 \\ \pi - \arcsin(y/h), \text{ for } h < 0 \\ 2\pi + \arcsin(y/h), \text{ for } h \geq 0 \text{ and } y < 0 \end{cases}$$

- `\Acost{}{}` gives a two-argument arc cosine (inverse cosine) that returns angles in the codomain $[0, 2\pi)$:

$$\mathrm{Arccos2}\,(x,h) = \begin{cases} \arccos(x/h), \text{ for } h \geq 0 \\ 2\pi - \arccos(x/h), \text{ for } h < 0 \end{cases}$$

- `\Atant{}{}` gives a two-argument arc tangent (inverse tangent) that returns angles in the codomain $[0, 2\pi)$:

$$\mathrm{Arctan2}\,(y,x) = \begin{cases} \arcsin(y/x), \text{ for } x \geq 0 \text{ and } y \geq 0 \\ \pi + \arcsin(y/x), \text{ for } x < 0 \\ 2\pi + \arcsin(y/x), \text{ for } x \geq 0 \text{ and } y < 0 \end{cases}$$

$$\phi = \phi(x,y,z) = \mathrm{Arctan2}\,(y,x)$$

- `\asint{}{}` gives a two-argument arc sine (inverse sine) that returns angles in the codomain $[-\pi/2, 3\pi/2)$:

$$\mathrm{arcsin2}\,(y,h) = \begin{cases} \arcsin(y/h), \text{ for } h \geq 0 \\ \pi - \arcsin(y/h), \text{ for } h < 0 \end{cases}$$

- `\acost{}{}` gives a two-argument arc cosine (inverse cosine) that returns angles in the codomain $[0, 2\pi)$:

$$\mathrm{arccos2}\,(x,h) = \begin{cases} \arccos(x/h), \text{ for } h \geq 0 \\ 2\pi - \arccos(x/h), \text{ for } h < 0 \end{cases}$$

- `\atant{}{}` gives a two-argument arc tangent (inverse tangent) that returns angles in the codomain $[-\pi/2, 3\pi/2)$:

$$\mathrm{arctan2}\,(y,x) = \begin{cases} \arcsin(y/x), \text{ for } x \geq 0 \\ \pi + \arcsin(y/x), \text{ for } x < 0 \end{cases}$$

## 5.9 Miscellaneous: Equation Labelling, Text in Mathmode, and Blackboard Bold

- `\={}` is for labelling an equal sign so that you may enumerate and explain the reasons for each equality.

$$x \overset{4}{=} z$$

  (We rename the existing command `\=` as `\baraccent` so that `\baraccent{a}` yields ā.)

- `\t{}` replaces `\text{}` so you can quickly insert text and upright roman letters in equations:
  `K_\t{e} = \frac{1}{4\pi\varepsilon_0} = \t{electrostatic Coulomb constant} \hspace{30pt}`
  `\t{and} \hspace{30pt} K_\t{m} = \frac{\mu_0}{4\pi} = \t{magnetostatic constant}` yields

$$K_\text{e} = \frac{1}{4\pi\varepsilon_0} = \text{electrostatic Coulomb constant} \hspace{30pt} \text{and} \hspace{30pt} K_\text{m} = \frac{\mu_0}{4\pi} = \text{magnetostatic constant}$$

  (We rename the existing command `\t{}` as `\taccent`)

- `\bb{}` replaces `\mathbb{}` so black board bold vectors don't take up too much space in your code.

$$\mathbf{x} \in \mathbb{R}^3$$

## 5.10 Space Management

- `\squishlist` Creates squished lists (lists with less inter-item spacing). Usage: put `\item` between `\squishlist` and `\squishend`, just like you would for a list or enumeration. As usual, you can add custom markers by using the optional argument for `\item`; see the examples in the entry below.

- `\squishlisti`, `\squishlistii`, `\squishlistiii` and are defined for easy nesting of "squished" lists, with differentiated item markers. All of them use `\squishend` to terminate. The default uses the symbols `\bullet`, `-`, `*`, and `\cdot` ($\bullet$, $-$, $*$, $\cdot$):

  – One
  – Two
    ∗ A
    ∗ B
      · do
      · re
    ∗ C
      · mi
  – Three

  but you can also give custom `\item` arguments, for example `\item[I.]` and `\item[$\diamondsuit$]` yield

  I. Open Symbols
    ♢ `\diamondsuit`
    ♡ `\heartsuit`
  II. Filled Symbols
    ♠ `\spadesuit`
    ♣ `\clubsuit`

- `\sp` is for adding space in an equation array so that you may have more than one relation while keeping uniform spacing: the aligned relations are surrounded by `&` signs, while the other relations are surrounded by `\sp`, which is really short for `\hspace{7pt}`.

$$\begin{aligned} E &= P + K \quad = \quad mc^2 + K \quad = \quad \gamma mc^2 \\ \gamma &\equiv \frac{1}{\sqrt{1-\beta^2}} \\ \beta &\equiv v/c \end{aligned}$$

- `\tstrut` and `\bstrut` are struts (spacing devices) that you can add to tabular structures (tabulars, tables). For example, the code

```
\begin{center}
\begin{tabular}{|l|}
 \hline
Simple random text written quickly. \\
Simple random text written quickly. \\
Simple random text written quickly. \\
 \hline
\end{tabular}
\end{center}
```

  yields

| |
|---|
| Simple random text written quickly.<br>Simple random text written quickly.<br>Simple random text written quickly. |

but the code

```
\begin{center}
\begin{tabular}{|l|}
 \hline
Simple random text written quickly. \tstrut\\
Simple random text written quickly. \\
Simple random text written quickly. \bstrut\\
 \hline
\end{tabular}
\end{center}
```

yields

| |
|---|
| Simple random text written quickly.<br>Simple random text written quickly.<br>Simple random text written quickly. |

- `\Tstrut` and `\Bstrut` are like `\tstrut` and `\bstrut` above but provide more space:

| |
|---|
| Simple random text written quickly.<br>Simple random text written quickly.<br>Simple random text written quickly. |

Using them with discretion can turn a table that looks like this:

| **"Remaining Maxwell Eqns"** (implied by constitutive relations) | |
|---|---|
| $\nabla\cdot\mathbf{H} = -\nabla\cdot\mathbf{M}$ | $\oint_S \mathbf{H}\cdot d\mathbf{a} = -\oint_S \mathbf{M}\cdot d\mathbf{a}$ |
| $\nabla\times\mathbf{D} + \frac{1}{c^2}\partial_t\mathbf{H} = \nabla\times\mathbf{P} - \frac{1}{c^2}\partial_t\mathbf{M}$ | $\oint_C \mathbf{D}\cdot d\mathbf{s} + \frac{1}{c^2}\partial_t\Phi_H = \oint_C \mathbf{P}\cdot d\mathbf{s} - \frac{1}{c^2}\partial_t\Phi_M$ |

into a table that looks like this

| **"Remaining Maxwell Eqns"** (implied by constitutive relations) | |
|---|---|
| $\nabla\cdot\mathbf{H} = -\nabla\cdot\mathbf{M}$ | $\oint_S \mathbf{H}\cdot d\mathbf{a} = -\oint_S \mathbf{M}\cdot d\mathbf{a}$ |
| $\nabla\times\mathbf{D} + \frac{1}{c^2}\partial_t\mathbf{H} = \nabla\times\mathbf{P} - \frac{1}{c^2}\partial_t\mathbf{M}$ | $\oint_C \mathbf{D}\cdot d\mathbf{s} + \frac{1}{c^2}\partial_t\Phi_H = \oint_C \mathbf{P}\cdot d\mathbf{s} - \frac{1}{c^2}\partial_t\Phi_M$ |

Examining the code, you'll see that the struts can be placed in such unlikely places as in the denominator of a fraction or in a subscript (see the code for the bottom row):

```
\begin{small}
\begin{center}
\begin{tabular}{|l|l|}
 \hline
\multicolumn{2}{|c|}{\textbf{‘‘Remaining Maxwell Eqns’’}
                     (implied by constitutive relations)}  \tstrut\\
 \hline\hline
$\div{\v{H}} = -\div{\v{M}}$
  &  $\oint_S \v{H}\cdot\d\v{a} = -\oint_S \v{M}\cdot\d\v{a}$  \Tstrut\Bstrut\\
$\curl{\v{D}} + \frac{1}{c^2}\p_t\v{H} = \curl{\v{P}} - \frac{1}{c^2}\p_t\v{M}$
  &  $\oint_C \v{D}\cdot\d\v{s} + \frac{1}{c^2}\p_t\Phi_H
          = \oint_C \v{P}\cdot\d\v{s} - \frac{1}{c^2}\p_t\Phi_{M\bstrut}$  \\
 \hline
\end{tabular}
\end{center}
\end{small}
```

# 6 Package Suggestions and Elaborations

## Suggestions

Here are some suggestions for packages that are not included in `PhysNote`.

- `srcltx` (for Unix-based system users)

  Aside from adding `\include{PhysNote}` to your file, if you are using an editor in a Unix-based system you should also add `\usepackage{srcltx}` to activate the "jump-to"/"forward search" and "jump-back"/"inverse search" features for viewing and editing. (When `\usepackage{srcltx}` is added within the file `PhysNote.tex`, the "inverse search" feature seems a bit buggy. Placing `\usepackage{srcltx}` in the main file works better.)

  About `srcltx` (from `srcltx.pdf`): Since this macro package overloads some internal LaTeX commands, it is not as robust as one might wish, and may interact badly with other packages. Furthermore, the spacing may be altered by using the package; for example, with the amsmath documentation `amsldoc.tex`, the bibliography is shifted from the bottom of page 31 to page 32. Therefore, you should comment out the package or disable it with the inactive option when preparing the final version of your document. Known incompatibilities with other packages: `soul.sty` and `syntax.sty`.

- `mathbbol` and `bbold` (blackboard bold packages)

  I've seen beautiful and effective usage of blackboard bold letters (on an actual chalkboard) to distinguish various forms of the same letter in their different usages (e.g., distinguishing $x$, $\vec{x}$, $x^\mu$, and $\mathbb{x}$, not to mention $\underline{x}$, $\bar{x}$, $\underset{\sim}{x}$, $\tilde{x}$, $\boldsymbol{x}$, or $\mathbf{x}$). The package `mathbbol` probably gives all the blackboard bold characters you'd ever want; the package `bbold` gives blackboard bold punctuation and other symbols, if you want that. Note, however, that you cannot (or, at least, I can't) use these packages in 11pt font size, hence this paper is in 10pt font size.

  - `mathbbol` (Options chosen: cspex, bbgreekl) provides blackboard bold font for upper-case and lower-case Latin and Greek letters, parentheses, and angled and square brackets. Beware that the code for the blackboard bold lower-case epsilon is misspelled as espilon, so you either have to write `\bbespilon` or correct the code in `mathbbol.sty`. Note also that `mathbbol` does not work for font size 11pt, since only the following exist: bbold5, bbold6, bbold7, bbold8, bbold9, bbold10, bbold12, and bbold17.

    See Table 1 for illustration.

| **Math mode** |
|---|
| `012...`: |
| $0123456789ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz$ |
| `\Gamma\Delta\Theta...`: |
| $\Gamma\Delta\Theta\Lambda\Xi\Pi\Sigma\Upsilon\Phi\Psi\Omega$ |
| `\alpha\beta\gamma...`: |
| $\alpha\beta\gamma\delta\epsilon\zeta\eta\theta\iota\kappa\lambda\mu\nu\xi\pi\rho\sigma\tau\upsilon\phi\chi\psi\omega$ |
| `\mathbb{012...}`: |
| $\mathbb{0123456789ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz}$ |
| `\mathbb{\Gamma\Delta\Theta...}`: |
| $\mathbb{\Gamma\Delta\Theta\Lambda\Xi\Pi\Sigma\Upsilon\Phi\Psi\Omega}$ |
| `\bbalpha\bbbeta\bbgamma...`: |
| $\mathbb{\alpha\beta\gamma\delta\epsilon\zeta\eta\theta\iota\kappa\lambda\mu\nu\xi\pi\rho\sigma\tau\upsilon\phi\chi\psi\omega}$ |
| `\Langle\Lbrack\Lparen...`: |
| $\Langle\Lbrack\Lparen\ldots\Rparen\Rbrack\Rangle$ |

Table 1: Using the *mathbbol* package.

Use `\hat{}` to create black board bold unit vectors:

$$\hat{\mathbb{\Gamma}}\hat{\mathbb{\Delta}}\hat{\mathbb{\Theta}}\hat{\mathbb{\Lambda}}\hat{\mathbb{\Xi}}\hat{\mathbb{\Pi}}\hat{\mathbb{\Sigma}}\hat{\mathbb{\Upsilon}}\hat{\mathbb{\Phi}}\hat{\mathbb{\Psi}}\hat{\mathbb{\Omega}}\hat{\mathbb{\alpha}}\hat{\mathbb{\beta}}\hat{\mathbb{\gamma}}\hat{\mathbb{\delta}}\hat{\mathbb{\epsilon}}\hat{\mathbb{\zeta}}\hat{\mathbb{\eta}}\hat{\mathbb{\theta}}\hat{\mathbb{\iota}}\hat{\mathbb{\kappa}}\hat{\mathbb{\lambda}}\hat{\mathbb{\mu}}\hat{\mathbb{\nu}}\hat{\mathbb{\xi}}\hat{\mathbb{\pi}}\hat{\mathbb{\rho}}\hat{\mathbb{\sigma}}\hat{\mathbb{\tau}}\hat{\mathbb{\upsilon}}\hat{\mathbb{\phi}}\hat{\mathbb{\chi}}\hat{\mathbb{\psi}}\hat{\mathbb{\omega}}$$

  - `bbold` provides blackboard bold font for upper-case and lower-case Latin letters, upper-case Greek letters, and numbers. (Supposedly, it should also produce blackboard bold lower-case Greek letters, but I could not figure out how to make them appear.)

See Table 2 for illustration.

| **Text mode** |
|---|
| `012...:` |
| 0123456789ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz |
| `\textbb{012...}:` |
| $\mathbb{0123456789ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz}$ |
| `\textbb{!@\#...}:` |
| !@#$%&()+-=[]‘’“”<>?,./ |
| **Math mode** |
| `012...:` |
| $0123456789ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz$ |
| `\Gamma\Delta\Theta...:` |
| $\Gamma\Delta\Theta\Lambda\Xi\Pi\Sigma\Upsilon\Phi\Psi\Omega$ |
| `\mathbb{012...}:` |
| $\mathbb{0123456789ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz}$ |
| `\mathbb{\Gamma\Delta\Theta...}:` |
| $\mathbb{\Gamma\Delta\Theta\Lambda\Xi\Pi\Sigma\Upsilon\Phi\Psi\Omega}$ |

Table 2: Using the *bbold* package.

## Elaborations

Here are some descriptions of packages that are included in `PhysNote`, elaborating upon what was written in the section *Packages Included* above.

- `ulem` allows for single underlining, double underlining, wavy underlining, simple strike-out with a single line drawn through the text, and hash-out with the text marked over with slashes, using these respective commands:
  - `\uline{}` Underline (Already adjusted for any descenders) (parentheses, same)
  - `\uuline{}` Under-Underline
  - `\uwave{}` Under-Wave
  - `\sout{}` ~~Strike-Out~~
  - `\xout{}` Hash-out

  Note that without this package, you already have the ability to do underlining with `\underline{}` and close/tight underlining with `\underline{\smash[b]{}}`, but each command behaves slightly differently:
  - `\underline{}` Underline (Adjusting for any descenders) (parentheses, adjusted)
  - `\underline{\smash[b]{}}` Smashed Underline (Going through any descenders) (parentheses, same)
- `accents` allows stacking of accents (and faked accents like $\star$) and under-accenting, along with shifting accents to match letter slanting. It also redefines `\dddot{}` and `\ddddot{}` to be more compact. (However, it doesn't correct the problem of losing bold-ness when putting a dot, using `\dot{}`, over a unit vector. See *Potential Problems and Errors* below.)

$$\overset{\star}{\hat{\mathring{\hat{\phi}}}} \qquad \underset{\sim}{n} = n_\mathrm{r} + i n_\mathrm{i}$$

$$\frac{\mathrm{d}^4}{\mathrm{d}t^4} f = \frac{\mathrm{d}^3}{\mathrm{d}t^3} \dot{f} = \frac{\mathrm{d}^2}{\mathrm{d}t^2} \ddot{f} = \frac{\mathrm{d}}{\mathrm{d}t} \dddot{f} = \ddddot{f}$$

$$\frac{\mathrm{d}}{\mathrm{d}t} \hat{\boldsymbol{\phi}} \neq \dot{\hat{\phi}} \qquad (\hat{\boldsymbol{\phi}} \text{ should remain bold under the dot.})$$

An example of an advantage provided by this package is the tilde under-accent: when writing the equation for a complex refractive index $\underset{\sim}{n}$ using complex relative permittivity $\underset{\sim}{\varepsilon}_r$, one might use the under-tilde to indicate complex-ness and write, for example, `\underset{\tilde{}}{\varepsilon}{}_r` yielding $\underset{\sim}{n} = \sqrt{\mu_r \underset{\sim}{\varepsilon}_r} =$

$\left(\mu_r \underaccent{\tilde}{\varepsilon}_r\right)^{1/2} = (\mu_r \underaccent{\tilde}{\varepsilon}_r)^{1/2} = n_n + i\kappa$. However, if one uses the `\underaccent{}{}` macro from the `accents` package, the spacing above and below will be more sensible: writing `\underaccent{\tilde}{\varepsilon}_r` yields $\underaccent{\tilde}{n} = \sqrt{\mu_r \underaccent{\tilde}{\varepsilon}_r} = (\mu_r \underaccent{\tilde}{\varepsilon}_r)^{1/2} = \left(\mu_r \underaccent{\tilde}{\varepsilon}_r\right)^{1/2} = n_n + i\kappa$.
Note that the `\underaccent{}{}` macro was used to define `\c{}` as described in the *Defined Macros* section above.

- `tensind` fixes tensor index positioning and makes tensor code more compact and aligned. Compare:

$$T_{\mu_1}{}^{\mu_2}{}_{\nu_1}{}^{\nu_2}{}_{\mu_3}{}^{\nu_3} \quad \neq \quad T_{\mu_1}{}^{\mu_2}{}_{\nu_1}{}^{\nu_2}{}_{\mu_3}{}^{\nu_3}$$

$$f^*_* \neq f^*_*$$

Here is the code for these expressions:

```
\[  {{{{{T_{\mu_1}}^{\mu_2}}_{\nu_1}}^{\nu_2}}_{\mu_3}}^{\nu_3}
    \sp\neq\sp  ?T_{\mu_1}^{\mu_2}_{\nu_1}^{\nu_2}_{\mu_3}^{\nu_3}?  \]
\[  f^*_* \neq ?f*_*? \]
```

# 7 Potential Problems and Errors

The first potential problem to note is that when a person uses a non-standard layout and macros in a LaTeX file, as is done when using `PhysNote.tex`, that person's file is no longer easily parsed or used by others unfamiliar with `PhysNote.tex` and its defined macros. (I should find a reference for this following comment:) Some people strongly warn against using non-standard packages and document types. However, if you're just trying to create some beautiful notes that utilize most of the surface area of the paper its printed on, and you're not worried too much about people looking at your LaTeX file and messing around with it, I don't think this is a problem.

Now, on to the other problems and errors:

- If you start your document with `\maketitle`, but without a section title (i.e., you don't use `\section{}`), your text will overlap with your title section. (The `\maketitle` code was optimized for documents with titles and section headings.) You'll have to add your own space either by starting your document with an empty, unnumbered section heading (`\section*{}` with nothing in the braces), or by manually inserting space with `\vspace{20pt}` (or some other amount), or by inserting `\indent`.
- If you include the package `dsfont` or `textcomp`, the spacing between the title section and the first section heading will be reduced. (It seems strange that a font file could do anything to the page layout.)
- I still occasionally have lines that run off the page when I use `\verb` and `\url{}` (`\url{}` is supposed to wrap and carry text to the next line).
- Using `\dot{}` on unit vectors (`\uv{}` and `\guv{}`) destroys their bold-ness.
  `\dot{\uv{s}}` and `\dot{\guv{\phi}}` yield $\dot{\hat{s}}$ and $\dot{\hat{\phi}}$.
  (Another strange thing is that in the past when I wrote `\dot{\guv{\phi}}`, an "s" would appear superimposed upon $\phi$!)

$$\dot{\hat{s}} \text{ and } \dot{\hat{\phi}}$$

$$\dot{\hat{s}} \text{ and } \dot{\hat{\phi}}$$

$$\begin{aligned} \dot{\hat{r}} &= \dot{\phi}\hat{\boldsymbol{\phi}} \\ \dot{\hat{\phi}} &= -\dot{\phi}\hat{\mathbf{r}} \\ \dot{\hat{z}} &= \mathbf{0} \end{aligned}$$

$$\begin{aligned} \dot{\hat{r}} &= \dot{\phi}\hat{\boldsymbol{\phi}} \\ \dot{\hat{\phi}} &= -\dot{\phi}\hat{\mathbf{r}} \\ \dot{\hat{z}} &= \mathbf{0} \end{aligned}$$

- `\taccent{}` does not return an accent as it should.

- It appears that one cannot use verbatim text (neither `\verb` nor `\begin{verbatim} \end{verbatim}`) in section headings or captions for figures and tables.
- The (suggested) packages `mathbbol` and `bbold`, which are not included in `PhysNote.tex`, do not allow 11pt font size, since only the following exist: bbold5, bbold6, bbold7, bbold8, bbold9, bbold10, bbold12, and bbold17.
- The (suggested) package `mathbbol`, which is not included in `PhysNote.tex`, does not allow math-style text (the math environment) in section headings, and neither does it allow the LaTeX logo command `\LaTeX` in section headings. (That's why the subtitle of this document, which uses the `mathbbol` package, has "LaTeX" rather than "LaTeX".)

# References


[1] Robert Dale, *et alia*: `http://www.ics.mq.edu.au/~rdale/resources/writingnotes/latexstruct.html#decl` (accessed 09 October 2006)

[2] Andrew J. Norman: `http://www.physics.wm.edu/~norman/latexhints/conditional_macros.html` (accessed 15 October 2006)

[3] Tim Love: `http://www-h.eng.cam.ac.uk/help/tpl/textprocessing/extending_latex.html` (accessed 18 December 2006)

[4] SourceForge.net (unkown author): `http://sourceforge.net/docman/display_doc.php?docid=19464&group_id=92412` (accessed 12 January 2007)

[5] A. Goreham, Michael J. Downes, Jim Hefferon, *et alia*: `http://www.ctan.org/installationadvice/` (accessed 12 January 2007)

# 8 Overview of Suggestions and PhysNote Contents

## 8.1 Suggested Packages

These packages are suggested, but not included in `PhysNote`.

- `srcltx`
- `mathbbol`
- `bbold`

## 8.2 Included Packages

These packages are included in `PhysNote`.

- `ifthen`
- `geometry`
- `multicol`
- `graphicx`
- `amsmath`
- `amsthm`
- `amssymb`
- `mathrsfs`
- `verbatim`
- `url`
- `accents`
- `tensind`
- `SIunits`
- `cancel`
- `ulem`

## 8.3 Defined Macros

- Subtitle Feature
  (1) Maketitle (redefined) `\maketitle`
  (2) Subtitle `\subtitle{}`
- Scientific Notation and Units
  (3) Scientific Notation `\sn{}{}`
  (4) Scientific Notation (with) Units `\snu{}{}{}`
- Points, Vectors, Coordinates, Operators, and Transforms
  (5) Complex `\c{}`
  (6) Fourier Transform `\ft{}`
  (7) Point `\p{}`
  (8) Vector `\v{}`
  (9) original `\v` → `\vaccent`
  (10) Greek Vector `\gv{}`
  (11) Unit Vector `\uv{}`
  (12) Greek Unit Vector `\guv{}`
  (13) Operator `\op{}`
  (14) Vector Operator `\vo{}`
  (15) Greek Vector Operator `\gvo{}`
  (16) Complex Vector `\cv{}`
  (17) Fourier Transformed Complex `\ftc{}`
  (18) Fourier Transformed Vector `\ftv{}`
  (19) Fourier Transformed Complex Vector `\ftcv{}`
  (20) Four Vector (abstract) `\fv{}`
  (21) Arbitrary Coordinate `\acoord[]{}`
  (22) Arbitrary Vector `\avector[]{}`
  (23) Three-Coordinate `\tcoord{}{}{}`
  (24) Vertical Three-Coordinate `\vtcoord{}{}{}`
  (25) (De)cartesian (three)-Coordinate `\dcoord{}{}{}`
  (26) Cylindrical (three)-Coordinate `\ccoord{}{}{}`
  (27) Spherical (three)-Coordinate `\scoord{}{}{}`
  (28) Three-Vector `\tvector{}{}{}`
  (29) Vertical Three-Vector `\vtvector{}{}{}`
  (30) (De)cartesian (three)-Vector `\dvector{}{}{}`
  (31) Cylindrical (three)-Vector `\cvector{}{}{}`
  (32) Spherical (three)-Vector `\svector{}{}{}`
  (33) Four-Coordinate `\fcoord{}{}{}{}`
  (34) Vertical Four-Coordinate `\vfcoord{}{}{}{}`
  (35) Four-Vector `\fvector{}{}{}{}`
  (36) Vertical Four-Vector `\vfvector{}{}{}{}`
- Inner Product, Norm, Absolute Value, and Average
  (37) Inner Product `\ip[]{}{}`
  (38) Norm `\norm[]{}`
  (39) Absolute value `\abs[]{}`
  (40) Average (or expectation) `\avg{}`
- Differentials
  (41) ordinary Differential `\d`
  (42) inexact Differential `\dbar`
  (43) general Differential `\D`
  (44) Functional Differential (Measure?) `\fD`
  (45) Partial differential `\p`
- Derivatives (auto, text, display, and "slash" modes)
  (46) Ordinary Derivative `\od[]{}{}`
  (47) Partial Derivative `\pd[]{}{}`
  (48) Partial Derivative (with) Constant (variables listed) `\pdc[]{}{}{}`
  (49) Mixed (partial) Derivative `\md{}{}{}{}{}{}`
  (50) Directional Derivative `\dd[]{}{}`
  (51) Functional Derivative `\fd[]{}{}`
  (52) Mixed Functional Derivative `\mfd{}{}{}{}{}{}`
  (53) Functional Directional Derivative `\fdd[]{}{}`
  (54) Capital D (Covariant Directional) Derivative `\cdd[]{}{}`
  (55) Gradient `\grad[]`
  (56) Divergence `\div[]{}`
  (57) original `\div` → `\divsymb`
  (58) Curl `\curl[]{}`
- Dirac and Feynman Notation (manual sizing)
  (59) (Dirac) Ket `\ket[]{}`
  (60) (Dirac) Bra `\bra[]{}`
  (61) (Dirac) Braket `\braket[]{}{}`
  (62) (Dirac) Ketbra `\ketbra[]{}{}`
  (63) (Dirac) Matrix Element `\matel[]{}{}{}`
  (64) (Dirac) Reduced Matrix El. `\redmatel[]{}{}{}`
  (65) (Feynman) Slash `\s{}`
- Trigonometrics
  (66) Sine `\S`
  (67) original `\S` → `\SS`
  (68) Cosine `\C`
  (69) Tangent `\T`
  (70) Arc Sine 2, codomain $[0, 2\pi)$: `\Asint{}{}`
  (71) Arc Cosine 2, codomain $[0, 2\pi)$: `\Acost{}{}`
  (72) Arc Tangent 2, codomain $[0, 2\pi)$: `\Atant{}{}`
  (73) Arc Sine 2, codomain $[-\pi/2, 3\pi/2)$ `\asint{}{}`
  (74) Arc Cosine 2, codomain $[0, 2\pi)$: `\acost{}{}`
  (75) Arc Tangent 2, codomain $[-\pi/2, 3\pi/2)$ `\atant{}{}`
- Miscellaneous: Equation Labelling, Text in Mathmode, and Blackboard Bold
  (76) Equal (sign label) `\={}`
  (77) original `\=` → `\baraccent`
  (78) Text `\t{}`
  (79) original `\t` → `\taccent`
  (80) Blackboard Bold `\bb{}`
- Space Management
  (81) Squishlist `\squishlist`, `\squishend`
  `\squishlisti`, `\squishlistii`, `\squishlistiii`
  (82) Space `\sp`
  (83) (small) top Strut `\tstrut`
  (84) (small) bottom Strut `\bstrut`
  (85) (large) Top Strut `\Tstrut`
  (86) (large) Bottom Strut `\Bstrut`