LaTeX 102

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Contents

1 Basic mathematics

In physics, we frequently encounter complicated mathematical expressions that need to be typeset. Typesetting mathematical expression in LaTeX is simple in principle but does require some practice. In fact, one may say that the soul of LaTeX is mathematics. Let's start our systematic learning of LaTeX mathematics.

Carefully read **Section 7.2** of [1]. You may wish to take notes and/or photocopy some pages. It's of paramount importance that you read **Section 7.2** of [1].

1.1 Exercise

Do **Exercise 7.2** on pages 125-126 of [1].
Hint: `\mathrm{i}` is used to denote $\sqrt{-1}$.

Save your TeX file as `username3.tex`, where `username` is your username.

1.2 Exercise

Do **Exercise 7.4** on page 126 of [1].

Save your TeX file as `username3.tex`, where `username` is your username.

1.3 Exercise

Do **Exercise 7.5** on page 126 of [1].
Hint: `\mathrm{d}x` is used for $\mathrm{d}x$.

Save your TeX file as `username3.tex`, where `username` is your username.

2 Mathematical symbols

Carefully read **Section 7.3** of [1]. You may wish to take notes and/or photocopy some pages. It's of paramount importance that you read **Section 7.3** of [1].

2.1 Exercise

Typeset **Exercise 7.6** on page 131 of [1].

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2.2 Exercise

Typeset **Exercise 7.7** on page 131 of [1].
Hint: Do this exercise in small chunks i.e., don't try to typeset the whole thing at once.

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2.3 Exercise

Typeset **Exercise 7.8** on page 131 of [1].

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2.4 Exercise

Do **Exercise 7.11** on page 131 of [1].

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2.5 Exercise

Typeset the following:

Output

$$\frac{\hbar^2}{2m}\nabla^2 = \frac{\hbar^2}{2m}\left(\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial z^2}\right)$$

Hint: Use `\left(  \right)` for ( ).

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3 Additional mathematical symbols

We frequently use bracketing to enclose part of the mathematical formula. The bracketing needs to be the same size as the enclosed part of the mathematical formula. For example,

$$\left(\frac{a}{b}\right)^2 \quad \text{and not} \quad (\frac{a}{b})^2.$$

The above is accomplished via `\left` and `\right` commands, for example:

Input

```
\[ \left( \frac{a}{b} \right) \]
\[ \left[ \frac{a}{b} \right] \]
\[ \left| \frac{a}{b} \right| \]
\[ \left\{ \frac{a}{b} \right\} \]
```

Output

$$\left(\frac{a}{b}\right)$$
$$\left[\frac{a}{b}\right]$$
$$\left|\frac{a}{b}\right|$$
$$\left\{\frac{a}{b}\right\}$$

Note that curly braces, { }, must be escaped, i.e., `\{ \}` not `{ }`.

3.1 Exercise

Read **Section 7.4.7** of [1] and then do **Exercise 7.17** on page 142 of [1].

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3.2 Exercise

Bold symbols in LATEX are achieved via `\boldsymbol{ }` command, e.g., `\boldsymbol{\Theta}` produces $\boldsymbol{\Theta}$.[1] Typeset the following paying close attention to the "boldness" of the symbols.

Output

$$\boldsymbol{\nabla} \cdot \boldsymbol{E} = 0$$
$$\boldsymbol{\nabla} \times \boldsymbol{E} = -\frac{\partial \boldsymbol{B}}{\partial t}$$

Save your TEX file as `username3.tex`, where `username` is your username.

3.3 Exercise

Typeset the following:

Output

$$E_x(\boldsymbol{r}) = \mathrm{e}^{-\mathrm{i}\boldsymbol{k}\cdot\boldsymbol{r}}\hat{\boldsymbol{\imath}}$$

Hints: `\mathrm{e}` is used if 'e' denotes the exp function. To produce 'i' or 'j' without the dot use `\imath` and `\jmath`, respectively.

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4 Other multiline environments

There is a whole slew of multiline environments provided by the `amsmath` package, e.g., `align`, `gather`, `falign`, `multline`, `alignat`, `split`. We won't use most of them but interested reader should read **Section 15.2.6** of [1]. The one "multiline environment" that we will use is the `cases` environment. The `cases` environment is used to typeset piecewise defined functions, for example:

[1] According to the International Standards Organization (ISO), vectors should be written in boldface italics. This rule is almost always violated in physics (don't ask why) by typesetting vectors in bold upright font. If you want to continue to violate the ISO rule use **mathbf** instead of **boldsymbol**, e.g., $\mathbf{E}$ instead of $\boldsymbol{E}$.

Input

```
\[ H(x) = %
  \begin{cases}
    0 & \text{if } x \leq 0 \\
    1 & \text{if } x > 0
  \end{cases}
\]
```

Output

$$H(x) = \begin{cases} 0 & \text{if } x \leq 0 \\ 1 & \text{if } x > 0 \end{cases}$$

Notice the strategic placement of the '&' character. The new line in the `cases` environment is started via `\\`. Below is another example of the `cases` environment.

Input

```
\begin{equation}
 H(x) = %
 \begin{cases}
   0 & \text{if } x<0 \\
   \frac{1}{2} & \text{if } x=0 \\
   1 & \text{if } x>0
 \end{cases}
\label{stepFunc}
\end{equation}
```

Output

$$H(x) = \begin{cases} 0 & \text{if } x < 0 \\ \frac{1}{2} & \text{if } x = 0 \\ 1 & \text{if } x > 0 \end{cases} \tag{1}$$

Eqn. (1) is known as Heaviside step function.

4.1 Exercise

Typeset the following:

Output

Derivative of

$$H(x) = \begin{cases} 0 & \text{if } x < 0 \\ 1 & \text{if } x > 0 \end{cases}$$

is given by

$$\delta(x) = \begin{cases} 0 & \text{if } x \neq 0 \\ \infty & \text{if } x = 0 \end{cases} \tag{2}$$

where $\delta(x)$ is the Dirac delta function. Strictly speaking, relation defined by (2) is not a function but rather a generalized function or a distribution.

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5 Dirac notation

If you continue your study of physics, you will encounter Dirac **bracket** notation. In this short section, we will learn the proper way to typeset the **bracket** notation. In order to typeset Dirac **bracket** notation with ease we need to add `bracket` package to our preamble via

```
\usepackage{braket}
```

notice that there is no 'c' in `braket`. The following syntax is used to typeset Dirac **bracket** notation:

Input

```
\[ \Bra{\Omega} \]
\[ \Ket{\Lambda} \]
\[ \Braket{\Omega | \Lambda} \]
\[ \Braket{\Omega |H| \Lambda} \]
```

Output

$$\langle\Omega|$$

$$|\Lambda\rangle$$

$$\langle\Omega\,|\,\Lambda\rangle$$

$$\langle\Omega\,|\,H\,|\,\Lambda\rangle$$

5.1 Exercise

Add `\usepackage{braket}` to the `username3.tex` preamble and then typeset the following:

Output

$$\frac{\mathrm{d}\langle F\rangle}{\mathrm{d}t} \equiv \left\langle \Psi \middle| \frac{\mathrm{d}F}{\mathrm{d}t} \middle| \Psi \right\rangle = \langle\Psi| \frac{\mathrm{d}F}{\mathrm{d}t} |\Psi\rangle$$

Hint: To produce $\langle F\rangle$ use `\langle F \rangle`.

Save your TEX file as `username3.tex`, where `username` is your username.

5.2 Exercise

Typeset the following:

Output

$$\hat{Q} = \sum_{j=1}^{n} \lambda_j \, |e_j\rangle \, \langle e_j|$$

Save your TEX file as `username3.tex`, where `username` is your username.

6 Matrices

Carefully read **Section 15.2.4** of [1] and then do the following exercises.

6.1 Exercise

Typeset the following matrix:

Output

$$\left\|\begin{matrix} \langle x_1 \,|\, x_1 \rangle & \langle x_1 \,|\, x_2 \rangle & \langle x_1 \,|\, x_3 \rangle & \langle x_1 \,|\, x_4 \rangle \\ \langle x_2 \,|\, x_1 \rangle & \cdots\cdots\cdots\cdots & & \langle x_2 \,|\, x_4 \rangle \\ \vdots & \vdots & \ddots & \vdots \\ \langle x_4 \,|\, x_1 \rangle & \langle x_4 \,|\, x_2 \rangle & \langle x_4 \,|\, x_3 \rangle & \langle x_4 \,|\, x_4 \rangle \end{matrix}\right\|$$

Save your TEX file as `username3.tex`, where `username` is your username.

7 Submit

Print out your `username1.pdf`, `username2.pdf`, `username3.pdf` files and turn them in for grading. Also, copy `username1.tex`, `username2.tex`, `username3.tex` files into `/Net/voodoo/home/ayuffa/FieldSession/` directory.

References

[1] Helmut Kopka and Patrick W. Daly, *Guide to LaTeX*, 4th edn (Addison-Wesley, 2004).