HANDSHAKE

LaTeX MASTER GUIDE

$$\lim_{n\to\infty} \sum_{k=1}^{n} \frac{n}{n^2+k^2} = \int_0^1 \frac{1}{1+x^2}\,dx$$

A Quick LaTeX Guide for Handshake Math Projects

Contents

Good mathematics is not just about getting the right answer, but about the right answer for the right reasons, explained in the right way.
–Sir Michael Atiyah, 1929-2019

1 Why Do We Need This Guide

The goal of this guide is to help fellows and reviewers know how and when to use LaTeX formatting in the Era platform. Although knowing LaTeX is a must for all mathematics students and mathematicians, using LaTeX properly in online platforms such as Era requires extra skills. Based on feedback from fellows and reviewers, it has become clear that many still have difficulty with math writing. This problem has caused significant complications in math projects because many tasks become stuck in cycles of LaTeX revisions. This issue encouraged the Handshake team to design a master LaTeX guide for all math projects. Of course, this is not a comprehensive LaTeX guide similar to the ones that can be found in many online resources. This guide only contains a collection of LaTeX codes and commands that are crucial for rendering math writing in the Era platform properly. It mainly aims to minimize the LaTeX mistakes that might be made by fellows. It can also help reviewers to quickly find the small errors in the LaTeX code of fellows and fix them without sending back the whole task.

The Handshake team is hoping that this LaTeX guide can improve the performance of both fellows and reviewers. Please send your suggestions and comments to valeria.andraka@joinhandshake.com.

2 Inline Math Mode

2.1 Text

Always use `$...$` for inline numbers and math variables, formulas, or expressions. In standard LaTeX editors, one can use `\(...\)` too, but this command does not render properly in the Era platform.
LaTeX:

```
Let $x$ be a real number such that $0 \le x \le \sqrt{8}$. What is the maximum
possible value of $x^2 - x +1$?
```

Render:

Let x be a real number such that $0 \le x \le \sqrt{8}$. What is the maximum possible value of $x^2 - x + 1$?

2.2 Lists

You can also use `$...$` in lists (see §10), whose items contain math formulas or expressions.
LaTeX:

```
If one factors the polynomial $P(x) = x^4 - 5x^3 + 5x^2 + 5x - 6$, the linear
factors are
  - $x-1$,
  - $x+1$,
  - $x-2$,
  - $x-3$.
```

Render:

If one factors the polynomial $P(x) = x^4 - 5x^3 + 5x^2 + 5x - 6$, the linear factors are

- $x - 1$,
- $x + 1$,
- $x - 2$,
- $x - 3$.

WARNING

NEVER use `\(...\)` for inline math mode.

3 Display Math Mode

3.1 Separate Lines

Always use `$$...$$` for display mode, when you want to put a math equation, formula or expression in a separate line.
LaTeX:

```
Consider the cubic equation
$$
x^3 - 4x^2 + 2x + 1 = 0.
$$
If $\lambda_1$, $\lambda_2$, and $\lambda_3$ are the real roots of the equation,
compute the value of $\lambda_1^3 + \lambda_2^3 + \lambda_3^3$.
```

Render:

Consider the cubic equation

$$x^3 - 4x^2 + 2x + 1 = 0.$$

If λ_1, λ_2, and λ_3 are the real roots of the equation, compute the value of $\lambda_1^3 + \lambda_2^3 + \lambda_3^3$.

3.2 Multi-Step Calculations

You can use `$$...$$` when you want to write an align environment (see §8) to do multi-step calculations.
LaTeX:

```
Factor the polynomial as follows:
$$
\begin{aligned}
f(x) &= x^3 - 4x^2 + 5x - 2\\
     &= x^3 - x - 4x^2 + 6x - 2\\
     &= (x-1)(x^2+x) - (x-1)(4x-2)\\
     &= (x-1)(x^2 + x - 4x + 2)\\
     &= (x-1)(x^2 - 3x + 2)\\
     &= (x-1)^2(x-2).
\end{aligned}
$$
```

Render:

Factor the polynomial as follows:

$$\begin{aligned} f(x) &= x^3 - 4x^2 + 5x - 2 \\ &= x^3 - x - 4x^2 + 6x - 2 \\ &= (x-1)(x^2+x) - (x-1)(4x-2) \\ &= (x-1)(x^2 + x - 4x + 2) \\ &= (x-1)(x^2 - 3x + 2) \\ &= (x-1)^2(x-2). \end{aligned}$$

WARNING

NEVER use `\[...\]` or `\begin{equation}...\end{equation}` for math display mode because the are not supported by the Era platform's rendering engine.

4 Math Symbols and Operators

General math characters, symbols, and operators must be written using proper LaTeX commands. For instance, instead of copying/pasting the Greek letter "theta", one should write `$\theta$` rendering as θ.

4.1 Math Symbols and Characters

A comprehensive list of LaTeX symbols and characters can be found in LaTeX Symbols. A few examples are given in the following table.

Symbol	LaTeX	Render
alpha	`$\alpha$`	α
pi	`$\pi$`	π
sqrt(2)	`$\sqrt{2}$`	$\sqrt{2}$

4.2 Multiplication Operation

Numbers

To show multiplication of numbers, one should use `\cdot` or `\times`.
LaTeX:

```
$$
2 \times 3 \times 5 = 2\cdot 3\cdot 5 = 30
$$
```

Render:

$$2 \times 3 \times 5 = 2 \cdot 3 \cdot 5 = 30$$

Variables

To show the product of variables and numbers, you can write them adjacent to each other without an explicit operator.
LaTeX:

```
$2x$, $3y$, $-3x^2$, $2xyz$, $-5a^3b^2c$ and so on.
```

Render:

$2x$, $3y$, $-3x^2$, $2xyz$, $-5a^3b^2c$ and so on.

Math Expressions

You can use brackets `(...)` and `[...]` to show multiplication between math expressions.
LaTeX:

```
If we multiply $x^2+x-1$ by $2x-1$, we have
$$
\begin{aligned}
(x^2+x-1)(2x-1) &= (x^2)(2x) - x^2 + (x)(2x) - x - 2x + 1\\
                &= 2x^3 - x^2 + 2x^2 - x  - 2x + 1\\
                &= 2x^3 + x^2 - 3x  + 1.
\end{aligned}
$$
```

Render:

If we multiply x^2+x-1 by $2x-1$, we have

$$\begin{aligned}(x^2+x-1)(2x-1) &= (x^2)(2x) - x^2 + (x)(2x) - x - 2x + 1\\ &= 2x^3 - x^2 + 2x^2 - x - 2x + 1\\ &= 2x^3 + x^2 - 3x + 1.\end{aligned}$$

WARNING

NEVER use `x` or `*` for multiplication.

4.3 Division Operation

Numbers

To show division of two numbers, you should use `\div` or `\frac{}{}`.
LaTeX:

```
$$
6 \div 3 = \frac{6}{3}  = 2
$$
```

Render:

$$6 \div 3 = \frac{6}{3} = 2$$

Sometimes to write fractions inside lines, the inclined short line (slash) / is used. This symbol is equivalent to the standard horizontal fraction line.
LaTeX:

```
Let $2/3$ of a right cone with height $h$ and radius $r$ be filled with water.
```

Render:

Let 2/3 of a right cone with height h and radius r be filled with water.

For more complex fractions (for instance, fractions of fractions), one can use the command \dfrac{}{}. This command is suitable for display mode.
LaTeX:

```
Simplify the following expression:
$$
\dfrac{(1 - \frac{1}{6})(\frac{1}{2} - \frac{1}{3})}{1 + \frac{3}{5}}.
$$
```

Render:

Simplify the following expression:

$$\dfrac{(1 - \frac{1}{6})(\frac{1}{2} - \frac{1}{3})}{1 + \frac{3}{5}}.$$

When dealing with continued fractions, the command \cfrac{}{} is useful.
LaTeX:

```
Show that
$$
1 + \cfrac{1}{2+\cfrac{1}{2+\cfrac{1}{2+\ddots}}} = \sqrt{2}.
$$
```

Render:

Show that

$$1 + \cfrac{1}{2 + \cfrac{1}{2 + \cfrac{1}{2 + \ddots}}} = \sqrt{2}.$$

Text

Sometimes, the fraction of two lines of text is needed (for example, for showing the units of quantities). In such cases, one may use \tfrac{}{}.
LaTeX:

```
For an acute angle $\alpha$ in a right triangle, we define
$$
\sin(\alpha) = \tfrac{\text{opposite}}{\text{hypotenuse}}.
$$
```

Render:

For an acute angle α in a right triangle, we define

$$\sin(\alpha) = \frac{\text{opposite}}{\text{hypotenuse}}.$$

Expressions

To show division of two math expressions, you should use `\frac{}{}` or `\dfrac{}{}`, depending on how complex the expressions are.
LaTeX:

```
When $x\ne 1$, simplify the following expression
$$
\frac{x^2-1}{x^3-4x+3}.
$$
```

Render:

When $x \ne 1$, simplify the following expression

$$\frac{x^2-1}{x^3-4x+3}.$$

LaTeX:

```
Simplify the following expression
$$
\dfrac{1-\dfrac{x^2-2}{x^4-4x+4}}{1+\dfrac{x+1}{x^2+x}},
$$
when the fractions are defined.
```

Render:

Simplify the following expression

$$\frac{1-\dfrac{x^2-2}{x^4-4x+4}}{1+\dfrac{x+1}{x^2+x}},$$

when the fractions are defined.

4.4 Some Special Operations

The following table gives a list of elementary operations and their LaTeX codes.

Operation	LaTeX	Render
Integral	`\int`	$\int$
Limit	`\lim`	$\lim$
Double integral	`\iint`	$\iint$
Triple integral	`\iiint`	$\iiint$
Partial derivative	`\partial`	∂
Sum	`\sum`	$\sum$
Product	`\prod`	$\prod$

A comprehensive list of math operations can be found in LaTeX Symbols.

4.5 Integrals

When dealing with integrals without limits, you can simply use `\int`, `\iint`, `\iiint` and so on.
LaTeX:

```
Let $S$ be the unit ball in $\mathbb{R}^3$ centered at the origin. Compute
$$
I = \iiint_{S} \frac{1}{x^2+y^2+z^2}\, dx\,dy\,dz.
$$
```

Render:

Let S be the unit ball in $\mathbb{R}^3$ centered at the origin. Compute

$$I = \iiint_S \frac{1}{x^2+y^2+z^2}\, dx\, dy\, dz.$$

You can also use `\limits{}` after the multiple integrals to put the domain below the integral signs.
LaTeX:

```
Let $S$ be the unit ball in $\mathbb{R}^3$ centered at the origin. Compute
$$
I = \iiint\limits_{S} \frac{1}{x^2+y^2+z^2}\, dx\,dy\,dz.
$$
```

Render:

Let S be the unit ball in $\mathbb{R}^3$ centered at the origin. Compute

$$I = \iiint\limits_S \frac{1}{x^2+y^2+z^2}\, dx\, dy\, dz.$$

When dealing with definite integrals, you should use `\int_{}^{}` or a sequence of them.
LaTeX:

```
Compute
$$
I = \int_1^2\int_1^2\int_1^2 \frac{1}{x^2y^2z^2}\, dx\,dy\,dz.
$$
```

Render:

Compute

$$I = \int_1^2 \int_1^2 \int_1^2 \frac{1}{x^2y^2z^2}\, dx\, dy\, dz.$$

For contour integrals, you can use `\oint` or `\oint_{}`.
LaTeX:

```
Let $f(z) = z^4$ and $C=\{z\in\mathbb{C}: |z-1|=3\}$. Compute
$$
I = \oint_{C} f(z)\, dz.
$$
```

Render:

Let $f(z) = z^4$ and $C = \{z \in \mathbb{C} : |z - 1| = 3\}$. Compute

$$I = \oint_C f(z)\, dz.$$

WARNING

NEVER use `\int\int` or `\int\int\int` for multiple integrations.

4.6 Sums and Products

When working with sums and products, one usually uses the subscript and superscript to show the limits: `\sum_{}^{}` and `\prod_{min}^{max}`. In some situations, the lower index requires extra conditions. In such cases, one can use `\sum_{\substack{ \\ }}^{}` and `\prod_{\substack{ \\ }}^{}`. Note that each `\\` creates one new line in the lower index.
LaTeX:

```
Evaluate
$$
\sum_{\substack{n=1\\ n \text{ is odd}}}^{\infty} \frac{1}{n^2}.
$$
```

Render:

Evaluate

$$\sum_{\substack{n=1 \\ n \text{ is odd}}}^{\infty} \frac{1}{n^2}.$$

4.7 Matrices

To write a matrix in LaTeX, you can use `\begin{pmatrix}...\end{pmatrix}` for curved matrices or `\begin{bmatrix}...\end{bmatrix}` for square matrices. For the determinant of a matrix, you can use `\begin{vmatrix}...\end{vmatrix}` or `\det`.
LaTeX:

```
$$
A = \begin{pmatrix}
1 & 2 \\
3 & 4 \\
\end{pmatrix},
A = \begin{bmatrix}
1 & 2 \\
3 & 4 \\
\end{bmatrix},
\det(A) = \begin{vmatrix}
1 & 2 \\
3 & 4 \\
\end{vmatrix}.
$$
```

Render:

$$A = \begin{pmatrix} 1 & 2 \\ 3 & 4 \end{pmatrix}, A = \begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix}, \det(A) = \begin{vmatrix} 1 & 2 \\ 3 & 4 \end{vmatrix}.$$

WARNING

Sometimes `\lvert\rvert` is also used for the determinant of a matrix.

4.8 Over and Under Symbols

To show a line segment or a vector between two points, you can use `\overline{}` and `\overrightarrow{}`, respectively.
LaTeX:

```
Consider the line segment $\overline{AB}$ and the vector $\overrightarrow{CD}$.
```

Render:

Consider the line segment $\overline{AB}$ and the vector $\overrightarrow{CD}$.

Sometimes one needs to show the number of objects in a sequence. One way to do that is to use `\underbrace{}_{}`.
LaTeX:

```
For any positive integer $n$, set
$$
a_n = \underbrace{222\ldots2}_{n \text{ times}} =
\overbrace{222\ldots2}^{n \text{ times}}.
$$
```

Render:

For any positive integer n, set

$$a_n = \underbrace{222\ldots2}_{n \text{ times}} = \overbrace{222\ldots2}^{n \text{ times}}.$$

4.9 Shorthand Symbols

Some LaTeX commands have alternative shortcuts. The following table lists some of those shortcuts.

Standard	Shortcut	Render
`\Longrightarrow`	`\implies`	$\Longrightarrow$
`\Longleftrightarrow`	`\iff`	$\Longleftrightarrow$
`\rightarrow`	`\to`	$\rightarrow$
`\neq`	`\ne`	$\neq$

4.10 Sets and Subsets

For denoting sets, one usually uses capital letters such as A, B, C, and so on. The empty set is always denoted by the command `\emptyset`. To show an element belongs to a set, the LaTeX command `\in` is

used. When you want to show the inclusion, you can use \subset or \subseteq. The latter is preferred because it means a subset of a set can be the whole set too.
LaTeX:

```
Let $x\in A\subset B$ and $B\cap C =\emptyset$.
Let $x\in A\subseteq B$ and $B\cap C =\emptyset$.
```

Render:

Let $x \in A \subset B$ and $B \cap C = \emptyset$.
Let $x \in A \subseteq B$ and $B \cap C = \emptyset$.

Relation	LaTeX	Render
x belongs to A	`x\in A`	$x \in A$
A is a subset of B	`A\subset B`	$A \subset B$
A is a subset of B	`A\subseteq B`	$A \subseteq B$
A is a proper subset of B	`A\\subsetneq B`	$A \subsetneq B$
A is not a subset of B	`A\nsubseteq B`	$A \nsubseteq B$

WARNING

Some authors use \subset for proper subsets.

4.11 Famous Math Sets

To show famous math sets such as integers, rationals and so on, you should use the command \mathbb{}. The following table contains the LaTeX codes of some of known sets.

Set	LaTeX	Render
Natural numbers	`\mathbb{N}`	$\mathbb{N}$
Integer numbers	`\mathbb{Z}`	$\mathbb{Z}$
Rational numbers	`\mathbb{Q}`	$\mathbb{Q}$
Real numbers	`\mathbb{R}`	$\mathbb{R}$
Complex numbers	`\mathbb{C}`	$\mathbb{C}$

WARNING

Although the set of natural numbers $\mathbb{N}$ traditionally refers to the set of counting numbers $\{1, 2, 3, \ldots\}$, some authors include 0 in this set. If you conclude 0 in $\mathbb{N}$, you should specifically state it in your tasks to avoid any confusion or ambiguity.

4.12 Congruency of Numbers

To show two integers are congruent modulo some integer, you can use \equiv along with \pmod{}.
LaTeX:

```
$$
25\equiv 1 \pmod{4}.
$$
```

Render:

$$25 \equiv 1 \pmod 4.$$

WARNING

NEVER use `=` instead of `\equiv` in a congruency equation.

5 Math Functions

5.1 Predefined Functions

To write special math functions such as sine and cosine, you should use their special LaTeX codes. For example, instead of writing `$sin(x)$`, you should use `$\sin(x)$`. The former renders as variables. LaTeX:

```
Let $\alpha$ be an acute angle in a right triangle. Show that
$$
\sin^2(\alpha) + \cos^2(\alpha) = 1.
$$
```

Render:

Let α be an acute angle in a right triangle. Show that

$$\sin^2(\alpha) + \cos^2(\alpha) = 1.$$

Some special functions are given in the following table

Function	LaTeX	Render
Sine	`\sin`	sin
Cosine	`\cos`	cos
Tangent	`\tan`	tan
Cotangent	`\cot`	cot
Arc Sine	`\arcsin`	arcsin
Arc Cosine	`\arccos`	arccos
Arc Tangent	`\arctan`	arctan
Logarithm	`\log`	log
Natural Logarithm	`\ln`	ln
Maximum	`\max`	max
Minimum	`\min`	min

A comprehensive list of math functions can be found in LaTeX Symbols.

WARNING

Although some authors use log for the natural logarithm to the base e, in elementary mathematics, log typically refers the common logarithm to the base 10. However, ln always refers to the natural logarithm to the base e.

5.2 Undefined Functions

There are some functions such as arccotangent or hyperbolic arccotangent, for which there are no predefined LaTeX commands. In such cases, one can use `\mathrm{}`.
LaTeX:

```
For any real number $x$ with $|x| > 1$, we have
$$
\mathrm{arccoth}(x) = \frac{1}{2}
\ln\left(\frac{x+1}{x-1}\right).
$$
```

Render:

For any real number x with $|x| > 1$, we have

$$\mathrm{arccoth}(x) = \frac{1}{2} \ln \left(\frac{x+1}{x-1} \right).$$

WARNING

NEVER use special functions without the backslash `\`.

6 Text Formatting

6.1 Plain Text

When writing plain text without any math symbols, it is usually not needed to use any LaTeX commands.
LaTeX:

```
There is a bag containing nine balls, three of which are red, two are blue
and four are green. Two balls are selected without replacing. What is the
probability that the two balls are green?
```

Render:

There is a bag containing nine balls, three of which are red, two are blue and four are green. Two balls are selected without replacing. What is the probability that the two balls are green?

6.2 Bold and Italic

To render bold and italic format of a word or phrase in Era, you need to use the markdowns `**...**` and `*...*`, respectively. The standard LaTeX commands `\textbf{}` and `\textit{}` are not supported by the Era platform.
LaTeX:

```
Let $z$ be a **complex** number. We say $z$ is a *root* of unity, if $z^n = 1$,
for some positive integer $n$.
```

Render:

Let z be a **complex** number. We say z is a *root* of unity, if $z^n = 1$, for some positive integer n.

WARNING

NEVER use `\textit{}` and `\textbf{}` in the Era platform.

6.3 Headings

When you want to use a heading for a text, you can use the markdown `#` before the text. The standard LaTeX commands do not render in the Era platform.
LaTeX:

```
# Case 1. $n$ is even
In this case, we have $n=2k$, for some integer $k$.
```

Render:

Case 1. n is even

In this case, we have $n = 2k$, for some integer k.

WARNING

NEVER use `\chapter{}`, `\section{}`, `\subsection{}` or similar commands in the Era platform.

6.4 Text in Math Environments

If you need to add a text to a math formula or expression, you need to use the command `\text{}`.
LaTeX:

```
Let
$$
A = \{x\in\mathbb{R}: x^2 < 2\}
$$
and
$$
B = \{x\in\mathbb{R}: x \text{ is a rational number}\}.
$$
What is the supremum of $A \cap B$?
```

Render:

Let

$$A = \{x \in \mathbb{R} : x^2 < 2\}$$

and

$$B = \{x \in \mathbb{R} : x \text{ is a rational number}\}.$$

What is the supremum of $A \cap B$?

Whatever one puts in the command `\text{}` renders exactly as it is. In particular, spaces render as spaces. The same is not true for math environments. It renders text as a long sequence of characters without any spaces between them. This is one of the main reasons to use `\text{}` for adding text to math formulas, equations or calculations.

Not using \text{}:

$$\{x \in \mathbb{R} : xisarationalnumber\}$$

Using \text{}:

$$\{x \in \mathbb{R} : x \text{ is a rational number}\}$$

Sometimes you need to use a text in the subscript or superscript of a math variable. It is required to use \text{} or \mathrm{}.
LaTeX:

```
Let $A_{\text{max}}$ and $A_{\mathrm{min}}$ be the maximum and the minimum of
the set $A = \{x\in\mathbb{R}: x^2\le 3\}$, respectively.
```

Render:

Let A_{max} and A_{min} be the maximum and the minimum of the set $A = \{x \in \mathbb{R} : x^2 \le 3\}$, respectively.

7 Tables

To write tables in standard LaTeX editors, one can use proper environments such as tabular. Unfortunately, these standard environments do not render in the Era platform. To do this, one can use a special table environment using vertical lines and dashes.
LaTeX:

```
|$x$| $y$ | $z$ |
|--|--|--|
| $1$ | $2$ | $2$ |
| $2$ | $3$ | $1$ |
| $1$ | $2$ | $0$ |
| $8$ | $1$ | $1$ |
| $2$ | $0$ | $10$ |
```

Render:

x	y	z
1	2	2
2	3	1
1	2	0
8	1	1
2	0	10

8 Align Environment

One of the most useful LaTeX commands needed in almost any math writing appears when one wants to do calculations in several steps. The command is $$\begin{aligned}...\end{aligned}$$. Each line in the environment should contain an ampersand & to indicate the alignment point and end with a double backslash \\ to indicate a line break.
LaTeX:

```
We can write
$$
\begin{aligned}
A &= \frac{1-\sqrt{2}}{1+\sqrt{2}}\\
  &= \frac{(1-\sqrt{2})(1+\sqrt{2})}{(1+\sqrt{2})^2}\\
  &= \frac{1-2}{1+2+2\sqrt{2}}\\
  &= \frac{-1}{3+2\sqrt{2}}\\
  &= \frac{-(3-2\sqrt{2})}{9-8}\\
  &= 2\sqrt{2}-3.
\end{aligned}
$$
```

Render:

We can write

$$
\begin{aligned}
A &= \frac{1-\sqrt{2}}{1+\sqrt{2}}\\
  &= \frac{(1-\sqrt{2})(1+\sqrt{2})}{(1+\sqrt{2})^2}\\
  &= \frac{1-2}{1+2+2\sqrt{2}}\\
  &= \frac{-1}{3+2\sqrt{2}}\\
  &= \frac{-(3-2\sqrt{2})}{9-8}\\
  &= 2\sqrt{2}-3.
\end{aligned}
$$

It should be noted that in some situations you can use $\leq$, $\geq$, $\cong$, or $\simeq$ in the place of equality.

WARNING

NEVER use `$...$` for alignment environment `\begin{aligned}...\end{aligned}`.

9 Case Environment

There are situations in which several equations need to be considered simultaneously. The most useful command is `\begin{cases}...\end{cases}`. The most famous example is to define functions with different formulas for different subsets of its domain.
LaTeX:

```
Consider the real-valued function $f:\mathbb{R}\to\mathbb{R}$ defined by
$$
f(x) = \begin{cases}
x^2 - x,  & \text{ if } x\le -1,\\
1 - x,    & \text{ if } -1 <x< 1,\\
x^3 - 1,  & \text{ if } x\ge 1.
\end{cases}
$$
```

Render:

Consider the real-valued function $f : \mathbb{R} \to \mathbb{R}$ defined by

$$f(x) = \begin{cases} x^2 - x, & \text{if } x \leq -1, \\ 1 - x, & \text{if } -1 < x < 1, \\ x^3 - 1, & \text{if } x \geq 1. \end{cases}$$

The case environment is also used for defining systems of equations.
LaTeX:

```
Solve the following system of linear equations
$$
\begin{cases}
2x + 3y - z = 0\\
3x - y - 2z = -1\\
x + y + z = 3.
\end{cases}
$$
```

Render:

Solve the following system of linear equations

$$\begin{cases} 2x + 3y - z = 0 \\ 3x - y - 2z = -1 \\ x + y + z = 3. \end{cases}$$

Sometimes the equations in a case environment are complicated and you need to consider more spaces between each case. The command `\begin{dcases}...\end{dcases}` can be used for such situations.
LaTeX:

```
Let
$$
f(x) =
\begin{dcases}
\frac{2-x}{1+\sqrt{x^2+x+1}}, & \text{ if } x\le 0,\\
\frac{\sqrt{x}+2}{2+x},       & \text{ if } 0 \le x \le 4,\\
\frac{2}{\sqrt{x}+1},         & \text{ if } x\ge 4.
\end{dcases}
$$
```

Render:

Let

$$f(x) = \begin{cases} \dfrac{2-x}{1+\sqrt{x^2+x+1}}, & \text{if } x \leq 0, \\ \dfrac{\sqrt{x}+2}{2+x}, & \text{if } 0 \leq x \leq 4, \\ \dfrac{2}{\sqrt{x}+1}, & \text{if } x \geq 4. \end{cases}$$

10 List Environments

Usually, in almost every standard LaTeX editor such as TeXstudio, TeXmaker, and Overleaf, one may use `\begin{itemize}...\end{itemize}` or `\begin{enumerate}...\end{enumerate}` to list items. In the Era platform, these list environments do not render properly. However, one can use alternative environments to list items.

10.1 Bulleted Lists

For bulleted lists, you can simply use a dash `-` in each line before the item and add as many items as you need in different lines.
LaTeX:

```
To show that $f$ is a homeomorphism, we need to show
 - $f$ is continuous.
 - $f$ is injective.
 - $f$ is surjective.
 - $f^{-1}$ is continuous.
```

Render:

To show that f is a homeomorphism, we need to show

- f is continuous.
- f is injective.
- f is surjective.
- f^{-1} is continuous.

Note that a space must always be placed before the dash to render the bulleted list.

10.2 Numbered Lists

For numbered lists, you can use numbers instead of a dash `-` in each line before the item and add as many items as you need.
LaTeX:

```
To show that $f$ is a homeomorphism, we need to show
 1. $f$ is continuous.
 2. $f$ is injective.
 3. $f$ is surjective.
 4. $f^{-1}$ is continuous.
```

Render:

To show that f is a homeomorphism, we need to show

1. f is continuous.
2. f is injective.
3. f is surjective.

4. f^{-1} is continuous.

Note that a space must always be placed before the number to render the numbered list.

11 Spacing

If you want to separate two parts by a thin space (for example, between differentials in a multiple integral), you can use `\,`. In some cases, the command `\text{ }` is also useful.

11.1 Spacing in Math Mode

When you need to put a small space between two parts of a math formula or expression, you can use `\,`.
LaTeX:

```
Compute
$$
I  = \int_{-\infty}^{+\infty} \frac{\sin(x)}{x}\, dx.
$$
```

Render:

Compute

$$I = \int_{-\infty}^{+\infty} \frac{\sin(x)}{x}\, dx.$$

This command is very useful in writing quantities with units.
LaTeX:

```
Let the velocity of a car be $v = 20\, \tfrac{\text{m}}{\text{s}}$.
```

Render:

Let the velocity of a car be $v = 20\, \frac{\text{m}}{\text{s}}$.

11.2 Spacing in Text

You can use `\text{}` in math mode to put spaces between words and math expressions or formulas.
LaTeX:

```
Let $A$ be the set of all rational numbers in the closed interval $[0,1]$:
$$
A = \{x\in\mathbb{R}: 0\le x \le 1 \text{ and } x \text{ is rational}\}.
$$
```

Render:

Let A be the set of all rational numbers in the closed interval $[0,1]$:

$$A = \{x \in \mathbb{R} : 0 \le x \le 1 \text{ and } x \text{ is rational}\}.$$

For longer than usual spaces, you can use the `\quad` command. This command is useful when you need to put a big space between equations or formulas in the display mode.
LaTeX:

```
The solution of the inequality is the union of the following sets:
$$
A = \{x\in\mathbb{R}: 0\le x \le 1\}\quad \text{and}\quad B = \{x\in\mathbb{R}:
-5\le x \le -1\}.
$$
```

Render:

The solution of the inequality is the union of the following sets:

$$A = \{x \in \mathbb{R} : 0 \le x \le 1\} \quad \text{and} \quad B = \{x \in \mathbb{R} : -5 \le x \le -1\}.$$

12 Dynamic Brackets

Sometime you need to put complicated expressions inside brackets to separate them. In these cases, using the common brackets `()`, `[]` and `{}` may not seem right. It is recommended to apply the dynamic brackets `\left(\right)`, `\left[\right]`, and `\left{\right}`, although `\left(\right)` covers most situations. The size of these brackets change according to the structure of the expression.
LaTeX:

```
Let $x$ be an integer. Solve for $x$:
$$
\left(\left(\left(\left(x+1\right)^{2x-1}\right)^{2x-1}\right)^{2x-1}
\right)^{2x-1} = 3^{81}.
$$
```

Render:

Let x be an integer. Solve for x:

$$\left(\left(\left((x+1)^{2x-1}\right)^{2x-1}\right)^{2x-1}\right)^{2x-1} = 3^{81}.$$

LaTeX:

```
For any real number $t\in(0,1)$, we have
$$
\begin{aligned}
\frac{d}{dt}\left(\int_{1}^{\frac{1}{t}} \frac{dy}{\sqrt[4]{y^4+1}}\right) &=
\left(-\frac{1}{t^2}\right)\left(\frac{1}{\sqrt[4]{(\frac{1}{t})^4+1}}\right)\\
&= \left(-\frac{1}{t^2}\right)\left(\frac{t}{\sqrt[4]{t^4+1}}\right)\\
&= \frac{-1}{t\sqrt[4]{t^4+1}}.
\end{aligned}
$$
```

Render:

For any real number $t \in (0,1)$, we have

$$\begin{aligned}\frac{d}{dt}\left(\int_1^{\frac{1}{t}} \frac{dy}{\sqrt[4]{y^4+1}}\right) &= \left(-\frac{1}{t^2}\right)\left(\frac{1}{\sqrt[4]{(\frac{1}{t})^4+1}}\right)\\ &= \left(-\frac{1}{t^2}\right)\left(\frac{t}{\sqrt[4]{t^4+1}}\right)\\ &= \frac{-1}{t\sqrt[4]{t^4+1}}.\end{aligned}$$

13 Absolute Values and Norms

To use the absolute value and the norm, some people just use common vertical lines | and ||. It is recommended to use the more standard commands `\lvert...\rvert` and `\lVert...\rVert` for the absolute value and the norm, respectively. To use dynamic versions of these symbols, enclose them in `\left...\right`.

LaTeX:

```
Let $x,y$ be real numbers such that $\lvert x\rvert \le 1$ and
$\lvert y\rvert \le 1$. Compute the maximum values of
$$
f(x,y) = \left\lvert \frac{x^2+y^2+3xy}{2}\right\rvert \quad\text{and}\quad
g(x,y) = \left\lVert \left(\dfrac{x}{2},\dfrac{y}{3}\right) \right\rVert^2.
$$
```

Render:

Let x, y be real numbers such that $|x| \le 1$ and $|y| \le 1$. Compute the maximum values of

$$f(x,y) = \left|\frac{x^2+y^2+3xy}{2}\right| \quad \text{and} \quad g(x,y) = \left\|\left(\frac{x}{2},\frac{y}{3}\right)\right\|^2.$$

14 Punctuation

A math equation or expression must always be punctuated as a part of a sentence containing it. In such cases, you should treat the equation as a phrase inside the sentence.

14.1 Inline Mode Punctuation

If you need to put a period or comma in an inline math equation or expression, you can add them after the math mode. Some authors insist on putting the comma or the period inside the inline math mode.

LaTeX:

```
Let $a$, $b$, and $c$ be real numbers such that $a^2 + b^2 + c^2 = 1$.
```

Render:

Let a, b, and c be real numbers such that $a^2 + b^2 + c^2 = 1$.

14.2 Display Mode Punctuation

If the last part of a sentence is a math formula or expression in the display mode, you must always put a period at the end of them to complete the punctuation. Note that the period must go inside the math mode.
LaTeX:

```
Let $a$, $b$, and $c$ be real numbers such that
$$
a^2 + b^2 + c^2 = 1.
$$
```

Render:

Let a, b, and c be real numbers such that

$$a^2 + b^2 + c^2 = 1.$$

Some authors prefer to put a thin space between the math formula or expression and the period. This is not mandatory here and is a matter of personal choice.
LaTeX:

```
Let $f:\mathbb{R}\to\mathbb{R}$ be a real-valued function such that
$$
f(x) = \frac{2x-1}{1+\sqrt{x^2+2}}\,.
$$
```

Render:

Let $f : \mathbb{R} \to \mathbb{R}$ be a real-valued function such that

$$f(x) = \frac{2x-1}{1+\sqrt{x^2+2}}\,.$$

15 Three Dots

In some situations, you need to use three successive dots to show a series of objects. To do this, you can use different kinds of dots: `\cdots`, `\ldots`, `\vdots` and `\ddots`.
LaTeX:

```
Consider the matrix $A$:
$$
A = \begin{pmatrix}
a_{1,1} & a_{1,2} & \cdots & a_{1,n} \\
a_{2,1} & a_{2,2} & \cdots & a_{2,n} \\
\vdots  & \vdots  & \ddots & \vdots \\
a_{n,1} & a_{n,2} & \cdots & a_{n,n} \\
\end{pmatrix}.
$$
```

Render:

Consider the matrix A:

$$A = \begin{pmatrix} a_{1,1} & a_{1,2} & \dots & a_{1,n} \\ a_{2,1} & a_{2,2} & \dots & a_{2,n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n,1} & a_{n,2} & \dots & a_{n,n} \end{pmatrix}.$$

Although, the two commands `\cdots` and `\ldots` look very similar, one should be careful using them. When listing the terms of a sequence, it is recommended to use `\ldots` rather than `\cdots`.
LaTeX:

```
Let $a_1, a_2, a_3, \ldots, a_n$ be $n$ positive integers.
```

Render:

Let $a_1, a_2, a_3, \ldots, a_n$ be n positive integers.

WARNING

NEVER use `...` for the three dots commands `\cdots` and `\ldots`.

16 Rounding Numbers

You are not allowed to round the final answer, unless you are required to do so. If the prompt specifies the number of decimal places for the final answer, you have to follow that and give the final answer accordingly.
LaTeX:

```
Since we have
$$
\sum_{n=1}^{\infty} \frac{1}{n^2} = \frac{\pi^2}{6},
$$
the value of the series up to three decimal places is $1.645$. Therefore,
the final answer is $\boxed{1.645}$.
```

Render:

Since we have

$$\sum_{n=1}^{\infty} \frac{1}{n^2} = \frac{\pi^2}{6},$$

the value of the series up to three decimal places is 1.645. Therefore, the final answer is $\boxed{1.645}$.

WARNING

NEVER use approximate values for known numbers like $\sqrt{2}$, e or π, unless the prompt specifically asks for it.

17 Python Code

To write a Python code in Era, you need to enclose your Python code in a pair of three back primes. The code renders in a black box in the Era platform.

Code:

The following Python function determines whether a positive integer $n > 1$ is prime:

```
def prime_finder(n):
    i = 2
    while i <= int(n**0.5):
        if n%i == 0:
            return False
            break
        else:
            i = i + 1
    else:
        return True
```

Render:

The following Python function determines whether a positive integer $n > 1$ is prime:

```
def prime_finder(n):
    i = 2
    while i <= int(n**0.5):
        if n%i == 0:
            return False
            break
        else:
            i = i + 1
    else:
        return True
```

WARNING

NEVER use three back primes for anything other than Python codes.

18 Ambiguous Language

18.1 Special Notations

The math topics considered in Handshake projects are very diverse and the contributors (fellows and reviewers) have various math backgrounds. Because of this diversity, a symbol or letter might have different meanings in different math fields. For example, for a topological space X, the suspension of X

is denoted by SX and the wedge sum of two spaces X, Y is $X \vee Y$. When using these notations in your writing, you should specify the meaning of SX and $X \vee Y$. Consider the following prompt:

Let X and Y be two topological spaces. Show that $S(X \vee Y)$ and $SX \vee SY$ are homotopy equivalent.

The problem with this prompt is that anyone who is not familiar with topology notation might not understand the meaning of $X \vee Y$ or SX and it is possible that they mix them up with something else and interpret them differently. To avoid this, one can rewrite the prompt as follows:

Let X and Y be two topological spaces. If SX denotes the suspension of X and $X \vee Y$ the wedge sum of X and Y, then show that $S(X \vee Y)$ and $SX \vee SY$ are homotopy equivalent.

18.2 Misinterpretation

To avoid ambiguity and to prevent others from personal interpretations, it is recommended that you be specific and define the unconventional notations and symbols you use in your writing. For example, consider

Let U be a neighborhood of x in the topological space X.

In most standard topological textbooks, a neighborhood U of a point x is a subset of X that contains an open set O such that $x \in O \subset U$. However, some authors consider a neighborhood U of x as an open set containing it. To avoid these two different interpretations, you can rewrite the statement as

Let U be a neighborhood of x in the topological space X, i.e., U contains an open set O such that $x \in O \subset U$.

or

Let U be a neighborhood of x in the topological space X, i.e., U is an open set containing x.

The main point here is that you should be as specific as possible in your writing to avoid confusion and ambiguity. Otherwise, your prompt might be rejected because of a misinterpretation.

19 Preamble and Packages

Some people use the standard format of a LaTeX file to write their prompts or solutions in online platforms such as Era. They define the preamble and start with `\begin{document}...\end{document}` or even add `\usepackage{...}` in their LaTeX code. This is not necessary and should be avoided. All these online platforms have already included all the required commands and packages. When writing your LaTeX code, do not worry about the required packages. All you need to do is to type your prompt or solution using the required LaTeX code.

20 How To Write Mathematics Like a Master

It is believed that the best way to learn how to write math essays rightly and efficiently is to read grand masters' books. Among the numerous standard math textbooks, there are some classical books that have made a great impact on the culture of mathematics for decades. It is safe to say that anyone who has studied mathematics at a graduate level has seen at least one of these books somewhere in their careers.

These grand masters not only are brilliant mathematicians, but also great writers. The following table lists the famous books of some of those grand masters.

Book	Author	Publisher
Principles of mathematical Analysis	Walter Rudin	McGraw Hill, 3rd Ed,1976
Real and Complex Analysis	Walter Rudin	McGraw Hill, 3rd Ed,1986
Topology	James Munkres	Pearson College Div, 2nd Ed, 2000
Introduction to Commutative Algebra	Michael F. Atiyah	Westview Press, 1994
Algebra	Thomas W. Hungerford	Springer, 1974
Linear Algebra	Kenneth M. Hoffman	Pearson, 2nd Ed, 1971
Topology from the Differentiable Viewpoint	John W. Milnor	Princeton University Press, 1997
Introduction to Topological Manifolds	John M. Lee	Springer, 2nd Ed, 2010
Calculus and Analytic Geometry	George B. Thomas	Addison Wesley, 1951
Algebraic Topology	Allen Hatcher	Cambridge University Press, 2001
Algebraic Geometry	Robin Hartshorne	Springer, 1977
Naive Set Theory	Paul Halmos	Springer, 1974

21 Suggested LaTeX Resources

There are many standard editors for writing LaTeX documents. In this section, we list some free LaTeX editors and applications that you can use for writing your math prompts.

TeXMaker: TexMaker is a free, modern and cross-platform LaTeX editor for Linux, Mac and Windows systems that integrates many tools needed to develop documents with LaTeX, in just one application.
https://www.xm1math.net/texmaker

TeXStudio: TeXStudio has been forked from TexMaker in 2009, because of the non-open development process of TexMaker and due to different philosophies concerning configurability and features.
https://www.texstudio.org

Overleaf: Overleaf was developed by researchers to make scientific and technical writing simpler and more collaborative. It is a free online editor.
https://www.overleaf.com/project

StackEdit: StackEdit renders mathematics from LaTeX expressions inside your markdown file, as you would do on Stack Exchange. It is a free online application to type and render LaTeX code.
https://stackedit.io

KaTeX: KaTex is a math typesetting library for the web. It is a free online editor to type LaTeX codes.
https://katex.org

Among the above-mentioned resources, KaTeX and StackEdit are the closest to the Era platform. If your LaTeX code renders properly in StackEdit or KaTeX, it most likely renders in the Era platform too. However, it is your own responsibility to ensure that your LaTeX code renders in Era properly before submitting your tasks.

Detexify

Sometimes you see math symbols that are not very familiar and finding their LaTeX commands might be very hard and time-consuming. There is a very useful and fun online application Detexify that can help you to find the right command. All you need to do is to draw the symbol in the box and it automatically generates the closest LaTeX command for you.