LaTeX: Online module 7

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Topics to be covered

- Introduction
- Typesetting formulas
- Equations
- Examples
- Exercises

Introduction

- One main advantages of LaTeX is typesetting mathematical equations
- This requires to tune the document manually
- Any sophisticated formulae can be handled: lengthy equations, matrices, various operators, etc
- Add the following packages into your preamble:

\usepackage{*amsmath*}

\usepackage{*amssymb*}

Mathematical modes

- There are two types of mathematical modes handled by LaTeX
  1. Inline mode: any equation or formula within text should start and end with a dollar sign $
  2. Display mode: any equation starts and ends with double dollar sign $$
- Equation mode: this mode generates automatically numbered equations (or, set of equations)
- Spacing is taken care off in the math mode

Inline mode

Example 1:

```
Since the function defined by $y=f(x)$ is one to one.
```

Output: Since the function defined by $y = f(x)$ is one to one.

Example 2:

```
Mathematical equations use greek alphabets such as $\alpha$,
 $\beta$, etc.
```

Output: Mathematical equations use greek alphabets such as α, β, etc.

Display mode

Example 1: If you want to display a formula without numbering use double dollar signs.

```
$$ x = a + b + c + d $$
```

Output:

$$x = a + b + c + d$$

Another example is:

```
$$ x^2 = y^2 + z^2 $$
```

Output:

$$x^2 = y^2 + z^2$$

Equation mode

All the equations should be enclosed within the following commands:

\begin{equation}
⋮
\end{equation}

If you want the following equation to be numbered

```
\begin{equation}
 x^2 = y^2 + z^2
\end{equation}
```

Output:

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

contd...

- Any number of equations can be written within the equation mode
- Set of equations get numbered automatically
- Double backward slash (\\) is used at the end of each equation
- Since, we want set of equations, we use the command for equation array:

\begin{eqnarray}
⋮
\end{eqnarray}

Example

```
\begin{eqnarray}
 x^2 = y^2 + z^2 \\
 a = b + c + d \\
 x = y + z
\end{eqnarray}
```

Output:

$$x^2 = y^2 + z^2 \tag{2}$$
$$a = b + c + d \tag{3}$$
$$x = y + z \tag{4}$$

Note: Numbering starts from (2) because one equation is numbered in slide number 7

Arithmetic operators

- Basic operations:

  `$x + y$, $x - y$, $xy$, $x/y$`

  Output: $x + y$, $x - y$, xy, x/y

- Multiplicative symbol or the dot symbol between numbers:

  `$x \times y$, $x \cdot y$`

  Output: $x \times y$, $x \cdot y$

- Fraction with and without display style command:

  `$\frac{x}{a + b}$ ; $\displaystyle{\frac{x}{a + b}}$`

  Output: $\frac{x}{a+b}$ and $\displaystyle\frac{x}{a+b}$

Note: Output looks much better when display style command is used

Greek letters

Use the following commands to get Greek letters:

- `$\Gamma$`
- `$\Delta$`
- `$\Theta$`
- `$\Lambda$`
- `$\Xi$`
- `$\Pi$`
- `$\Sigma$`
- `$\Upsilon$`
- `$\Phi$`
- `$\Psi$`
- `$\Omega$`

to get the output as: Γ, Δ, Θ, Λ, Ξ, Π, Σ, Υ, Φ, Ψ, Ω

contd...

- `$\alpha$`
- `$\beta$`
- `$\gamma$`
- `$\delta$`
- `$\pi$`
- `$\epsilon$`
- `$\varepsilon$`
- `$\zeta$`
- `$\eta$`

to get the output as α,β, γ, δ, π, ϵ, ε, ζ, η

contd...

- `$\theta$`
- `$\phi$`
- `$\varphi$`
- `$\tau$`
- `$\lambda$`
- `$\mu$`
- `$\nu$`

to get the output as θ, ϕ, φ, τ, λ, μ, ν

Subscript and superscript

Sub scripts and super scripts should be enclosed by curly braces

- Subscript:

  ```
  $y = f(x_{1} , x_{2}, x_{3}, .... , x_{n})$
  ```

  Output: $y = f(x_1, x_2, x_3, \ldots, x_n)$

- Superscript:

  ```
  $y = f(x^{2} , y^{2}, z^{2})$
  ```

  Output: $y = f(x^2, y^2, z^2)$

Inequalities

- **not equal to**: use \not =
- **less than**: use <
- **less than or equal to**: use \leq
- **not less than or equal to**: use \not\leq
- **greater than**: use >
- **greater than or equal to**: use \geq
- **not greater than or equal to**: use \not\geq

Root

- Command for square root is: \sqrt

  ```
  $y = \sqrt{a+b}$
  ```

  Output: $y = \sqrt{a+b}$
- Command for nth root is: \sqrt[n]

  ```
  $y = \sqrt[n]{a+b}$
  ```

  Output: $y = \sqrt[n]{a+b}$

Sums and products

- Command for sum is: \sum

  ```
  $\sum_{i=1}^{n} a_{i}$
  ```

  Output: $\sum_{i=1}^{n} a_i$
- Command for product is: \prod

  ```
  $\prod_{i=1}^{n} a_{i}$
  ```

  Output: $\prod_{i=1}^{n} a_i$
- Combination of sum and product

  ```
  $\prod_{i=1}^{n} b_{i} \sum_{j=1}^{i} a_{j}$
  ```

  Output: $\prod_{i=1}^{n} b_i(\sum_{j=1}^{i} a_j)$

  (**Note**: summation is from $j = 1$ to $j = i$)

Text within equations

- Text can be placed within an equation by using the command \mbox

```
$x = y + z \mbox{(hypothesis)}$
```

Output: $x = y + z\text{(hypothesis)}$

- Observe that there is a spacing issue in the above equation, we introduce a spacing command

```
$x = y + z \mbox{\, (hypothesis)}$
```

Output: $x = y + z \ \text{(hypothesis)}$

```
$x = y + z \mbox{\quad hypothesis}$
```

Output: $x = y + z \quad \text{(hypothesis)}$

```
$x = y + z \mbox{\qquad hypothesis}$
```

Output: $x = y + z \qquad \text{(hypothesis)}$

contd...

Here is another example:

```
\begin{eqnarray}
x = y + z \mbox{\qquad hypothesis} \\
a = \displaystyle{\frac{b}{c}}\mbox{\qquad since $c>0$}
\end{eqnarray}
```

Output:

$$x = y + z \qquad \text{from hypothesis} \tag{5}$$

$$a = \frac{b}{c} \qquad \text{is defined when } c > 0 \tag{6}$$

Trigonometric functions

Any trigonometric function should be preceded by a \

- `$\sin$`
- `$\cos$`
- `$\tan$`
- `$\csc$`
- `$\sec$`
- `$\cot$`

to get the output as sin, cos, tan, csc, sec, cot.

Note: The same holds for inverse trigonometric and hyperbolic functions

Over brace and under brace

- Command to use over brace: \overbrace{*contenthere*}

```
$x = w + \overbrace{y + z}^{\mbox {when $z>0$}}$
```

Output: $x = w + \overbrace{y + z}^{\text{when } z > 0}$

- Command to use under brace: \underbrace{*contenthere*}

```
$x = w + \underbrace{y + z}_{\mbox {when $z>0$}}$
```

Output: $x = w + \underbrace{y + z}_{\text{when } z > 0}$

- Command to use overline: \overline{*contenthere*}

```
$x = w + \overline{y + z}$
```

Output: $x = w + \overline{y + z}$

Integrals and limits

- Command to use integral is \int: lower limit is a sub script and upper limit is a super script

  ```
  $\displaystyle{\int_{0}^{1} \frac{x}{1+x^{2}}} \, dx$
  ```

  Output: $\displaystyle{\int_{0}^{1} \frac{x}{1+x^{2}}} \, dx$

- Command to use limit: \lim

  ```
  $\lim_{x\rightarrow 0} \displaystyle{\frac{x}{1+x^{2}}}$
  ```

  Output: $\lim_{x\rightarrow 0} \displaystyle{\frac{x}{1+x^{2}}}$

contd...

- If you want the limits also to be displayed after integration:

```
$\displaystyle{\int_{0}^{1} 1+x} \, dx
= \left[x + \frac{x^{2}}{2}\right]_{0}^{1}$
```

Output is the following:

$$\int_0^1 1 + x \, dx = \left[x + \frac{x^2}{2}\right]_0^1$$

Alignment

- amsmath package helps LaTeX to align the equations
- Advantage: used to break up lengthy and complicated equations
- Commands to align set of equations is:

```
\begin{align}
    ⋮
\end{align}
```

contd...

```
\begin{align}
x &= y + z \\
a + b &= \alpha^{2} \\
x^{2} + y^{2} &= \frac{\alpha}{\beta}
\end{align}
```

Output:

$$x = y + z \tag{7}$$

$$a + b = \alpha^2 \tag{8}$$

$$x^2 + y^2 = \frac{\alpha}{\beta} \tag{9}$$

Cases environment

```
$f(x)=
\begin{cases}
x^{2}, &\text{if $-1 \leq x \leq 1$;}\\
x, &\text{if $2 \leq x \leq 10$;}\\
0, &\text{otherwise.}
\end{cases}$
```

Output: $f(x) = \begin{cases} x^2, & \text{if } -1 \leq x \leq 1; \\ x, & \text{if } 2 \leq x \leq 10; \\ 0, & \text{otherwise.} \end{cases}$

Factorial, binomial, modulus

- Command to use factorial is: !

  `$f(x)= n!$`

  Output: $f(x) = n!$
- Command for binomial: \binom (Notice the difference in the formula using display style command)

  `$\binom{n}{r}$;  $\displaystyle{\binom{n}{r}}$`

  Output: $\binom{n}{r}$; $\displaystyle\binom{n}{r}$
- Modulus: you can use the command \lvert and \rvert

  `$\sqrt{x^{2}} = \lvert x \rvert$`

  Output: $\sqrt{x^2} = |x|$

Exercises

- Try to reproduce the following equations along with the text:

$$ax^2 + bx + c = 0 \quad \text{(form of quadratic equation)} \tag{10}$$

$$x^2 = a + b + \frac{1}{c} \tag{11}$$

$$x + y + z = 1 \tag{12}$$

- Set of equations that include fraction, square root:

$$x_1 = \frac{-b + \sqrt{b^2 - 4ac}}{2a} \tag{13}$$

$$x_2 = \frac{-b - \sqrt{b^2 - 4ac}}{2a} \tag{14}$$

contd...

- Equation that include sum and product:

$$\sum_{i=1}^{n} b_i \left(\prod_{j=1}^{i} a_j \right) \tag{15}$$

- Equation that includes limits and integrals:

$$\lim_{y \to 0} \int_0^1 \frac{x}{y + x^2} \, dx \tag{16}$$

contd...

- Equation that has under braces and cases:

$$h(x) = \begin{cases} ax + bx^2 + cx^3, & \text{if } 0 \leq a \leq 1,\ b \geq 10,\ c \neq 0; \\ \dfrac{ax + bx^2}{\underbrace{n(n-1)...1}_{\text{which is equal to } n!}}, & \text{if } a \neq 0 \end{cases}$$