STA 322 - Assignment

LaTeX Document

Francis Muti - I63/1176/2018

A LaTeX document to showcase scientific writing and use of mathematical symbols.

UNIVERSITY OF NAIROBI

School of Mathematics
University of Nairobi
May 15, 2021

Introduction

For this assignment, I worked on different mathematical formulas in LaTeX. I was guided by Jason Gross' LaTeX exercises (1).

1 Latex Exercise

1.1 Easy

$$\text{Please type me! The quick brown fox jumps over the lazy dog} \tag{1}$$

$$e^{i\pi} + 1 = 0 \tag{2}$$

$$e^{i\theta} = \cos\theta + i\sin\theta \tag{3}$$

$$G_{\mu v} + \Lambda g_{\mu v} = \frac{8\pi G}{c^4} T_{\mu v} \tag{4}$$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \tag{5}$$

$$\vec{L} = \vec{r} \times \vec{p} \tag{6}$$

$$\sqrt[3]{2} \tag{7}$$

$$(x+y)^n = \sum_{r=0}^{n} \binom{n}{r} x^r y^{n-r} \tag{8}$$

$$\sqrt{\frac{a_1^2 + \cdots + a_n^2}{n}} \geq \frac{a_1 + \cdots + a_n}{n} \geq \sqrt[n]{a_1 \ldots a_n} \geq \frac{n}{\frac{1}{a_1} + \cdots + \frac{1}{a_n}} \tag{9}$$

$$|\langle x, y \rangle|^2 \leq \langle x, x \rangle \cdot \langle y, y \rangle \tag{10}$$

$$\begin{aligned} &\textbf{A1: } \varphi \longrightarrow (\psi \to \varphi) \\ &\textbf{A2: } (\varphi \to (\psi \to \theta)) \longrightarrow ((\psi \to \varphi) \to (\phi \to \theta)) \\ &\textbf{A3: } (\neg\varphi \to \neg\psi) \longrightarrow (\psi \to \varphi) \end{aligned} \tag{11}$$

1.2 Medium

$$1_A = \begin{cases} 1 & \text{if } x \in A \\ 0 & \text{if } x \notin A \end{cases} \tag{12}$$

$$\underbrace{n \uparrow \ldots \uparrow}_{n} n = n \to n \to n \tag{13}$$

In the following, not the spacing between the = and the ${}^{1}1$, ${}^{2}2$, and ${}^{3^3}3$

$$\begin{aligned} 1 \uparrow 1 &= {}^{1}1 = 1 \\ 2 \uparrow\uparrow 2 &= {}^{2}2 = 4 \\ 3 \uparrow\uparrow\uparrow 3 &= {}^{3^3}3 = 3 \uparrow\uparrow 3 \uparrow\uparrow 3 = \underbrace{3^{3^{3^{3^{3^{3^{3^{\cdot^{\cdot^{\cdot^{3}}}}}}}}}}}_{3^{3^3} \text{ threes}} \end{aligned} \tag{14}$$

$$\frac{\mathrm{d}}{\mathrm{d}x} = \lim_{\Delta x \to 0} \frac{f(x + \Delta x) - f(x)}{\Delta x} \tag{15}$$

$$\mathrm{H_2O}(\ell) + \mathrm{H_2O}(\ell) \leftrightharpoons \mathrm{H_3O^+}(aq) + \mathrm{OH^-}(aq) \tag{16}$$

$$\Gamma(n+1) \stackrel{def}{=} \int_0^\infty e^{-t} t^n \mathrm{d}t \tag{17}$$

$$\gcd(n, m \bmod n); \quad x \equiv y \pmod{b}; x \equiv y \pmod{c}; \quad x \equiv y \pod{d} \tag{18}$$

In the following, note the bold symbols.

$$\begin{aligned} \nabla \cdot \mathbf{E} &= \frac{\rho}{\varepsilon_0} \\ \nabla \cdot \mathbf{B} &= 0 \\ \nabla \times \mathbf{E} &= -\frac{\partial \mathbf{B}}{\partial t} \\ \nabla \times \mathbf{B} &= \mu_0 \mathbf{J} + \mu_0 \varepsilon_0 \frac{\partial \mathbf{B}}{\partial t} \end{aligned} \tag{19}$$

For the following exercise, you will need to use `\usepackage {esint}` to get the symbol $\oiint$.

$$\begin{aligned} \oiint_{\partial V} \mathbf{E} \cdot \mathrm{d}\,\mathbf{A} &= \frac{\mathcal{Q}(V)}{\varepsilon_0} \\ \oiint_{\partial V} \mathbf{B} \cdot \mathbf{A} &= 0 \\ \oint_{\partial S} \mathbf{E} \cdot \mathrm{d}\mathbf{l} &= -\frac{\partial \Phi_{B,S}}{\partial t} \\ \oint_{\partial S} \mathbf{B} \cdot \mathrm{d}\mathbf{l} &= \mu_0 \mathbf{I}_S + \mu_0 \varepsilon_0 \frac{\partial \Phi_{B,S}}{\partial t} \end{aligned} \tag{20}$$

You might find the environment `bmatrix` and `pmatrix` useful for the following exercises.

$$\rho\theta = \begin{pmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{pmatrix} = \begin{bmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{bmatrix} \tag{21}$$

$$\left[\begin{array}{c|cccc} 1 & 0 & \cdots & 0 \\ \hline 0 & * & \cdots & * \\ \vdots & \vdots & \ddots & \vdots \\ 0 & * & \cdots & * \end{array}\right] = \boxed{\begin{array}{c|cccc} 1 & 0 & \cdots & 0 \\ \hline 0 & * & \cdots & * \\ \vdots & \vdots & \ddots & \vdots \\ 0 & * & \cdots & * \end{array}} \tag{22}$$

Note the locations of the bounds on the summation in the following exercise.

$$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N} p_i(x_i - \bar{x})^2} = \sqrt{\frac{\sum_{i=1}^{N} p_i(x_i - \bar{x})^2}{N}} \tag{23}$$

$$\varphi(n) = n \cdot \prod_{\substack{p \mid n \\ p \text{ prime}}} (1 - \frac{1}{p}) \tag{24}$$

If you `\usepackage {mathtools}`, you can make it look like

$$\varphi(n) = n \cdot \prod_{\substack{p \mid n \\ p \text{ prime}}} (1 - \frac{1}{p}) \tag{25}$$

$$ {}^{4}_{12}\mathbf{C}^{5+}_{2} \quad {}^{14}_{2}\mathbf{C}^{5+}_{2} \quad {}^{4}_{12}\mathbf{C}^{5+}_{2} \quad {}^{14}\mathbf{C}^{5+}_{2} \quad {}_{12}\mathbf{C}^{5+}_{2} \tag{26}$$

In the following, note the size of `/`, and the spacing on the sizes of the `|`.

$$\begin{gathered} \mathbb{Q} \cong \left\{ \frac{a}{b} \,\middle|\, a, b \in \mathbb{Z} \text{ and } b \neq 0 \right\} \Big/ \sim \\ \frac{a}{b} \sim \frac{c}{d} \iff ad - bc = 0 \end{gathered} \tag{27}$$

Notice both the horizontal and vertical spacing in the following exercise.

$$\begin{aligned} 1 \uparrow 1 &= {}^{1}1 = 1 \\ 2 \uparrow\uparrow 2 &= {}^{2}2 = 4 \\ 3 \uparrow\uparrow\uparrow 3 &= {}^{3^3}3 = 3 \uparrow\uparrow 3 \uparrow\uparrow 3 = \underbrace{3^{3^{3^{3^{3^{3^{\cdot^{\cdot^{\cdot^{3}}}}}}}}}}_{3^{3^3} \text{ threes}} \end{aligned} \tag{28}$$

1.3 Insane

Write a command `outputcode` which outputs the code of the document being typeset. (2)

Primes (1 - 10): 2, 3, 5, 7
Primes (1 - 20): 2, 3, 5, 7, 11, 13, 17, 19
Primes (50 - 100): 53, 59, 61, 67, 71, 73

1.4 Diabolical

The Ackermann function is defined as (3)

$$A(m,n) = \begin{cases} n+1 & \text{if } m = 0 \\ A(m-1,1) & \text{if } m > 0 \ \text{ and } \ n = 0 \\ A(m-1, A(m,n-1)) & \text{if } m > 0 \text{ and } n > 0 \end{cases}$$

Only outputs the result.
$ackermann(2,2) = 7$
$ackermann(1,2) = 4$

References

[1] Jason Ross, LaTeXExercises
https://web.mit.edu/ jgross/Public/latex/exercises.pdf

[2] Primes in LaTeX
https://tex.stackexchange.com

[3] Ackermann Function
https://tex.stackexchange.com/questions/584112/ackermann-function