LaTeX Seminar for MATB24 TUT5

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1 LaTeX is useful when typing mathematics!

1.1 This is a subsection under this section

I don't like the label!

1.1.1 This is a subsubsection!

This helps you make everything organized.

This is amazing! Wait, why is there an indentation?

This looks better now! However, keep in mind that the following make no differences even if you indent in your TeX code:
Hi, this is the first one.
Hi, this is the first one.

2 Make a list instead of a paragraph

Instead of writing a paragraph, you can make a list as follows.

- Hi!
- This looks much better now!

Oh! This is not in the list.

1. Here is another way to make a list
   (a) Similar to the idea of subsection.
   (b) This is why indentation in your TeX code is helpful, so that you do not easily get confused

3 Typing in math mode

How should we type in math? For example, if we want to type the equation 1+1=2 and f(x)=x?
No, it should be $1 + 1 = 2$ and $f(x) = x$. Math should be typed under the math mode with the dollar signs. However, be careful if you type non-math under math mode. For example,

- $I like linear algebra and 1 + 1 = 2 is easy!$. This does not look good!
- You should write it as: I like linear algebra and $1 + 1 = 2$ is easy!
- With the amsmath package, I like linear algebra and $1 + 1 = 2$ is easy!

Besides, you can also do the following

$$1 + 1 = 2 \text{ is important!}$$

instead of $1 + 1 = 2$ is important!

3.1 amsfonts package is very useful!

Remember, R is not representing the set of all real numbers! R is also not what we wanted. The correct form should be $\mathbb{R}$ with the amsfonts package. Similarly, we have seen $\mathbb{C}, \mathbb{Q}$. Here is something fancy we can type with the package, $\mathbb{P}_n(\mathbb{R})$ which is the set of all polynomial with degree at most n and coefficients in $\mathbb{R}$.

3.2 subscript and superscript

Remember as we have seen in linear algebra, we have often used subscript and superscript when writing math. Similarly, we can do it in LaTeX. For example, a_1 and a_1 are representing the same things, but $a_r + 1$ and a_{r+1} is different, because the brackets tell LaTeX that $r + 1$ is the subscript.
Similarly, a^2 and a^2 are representing the same things, but $a^r + 1$ and a^{r+1} are different! Together, we can have something fancy now a_i^{k+1} or more careful $(a_i)^{k+1}$.
Notice 1 is the same as 1. So to type the brackets in LaTeX, you need to do the following: {1}. The backslash tells LaTeX that that is not a command, it is just a symbol!

3.3 Example: Definition of linearly independent

Let $S = \{v_1, \cdots, v_n\}$ be a set of vectors in the vector space V, we say that S is linearly independent if

$$a_1v_1 + \cdots + a_nv_n = 0 \text{ for some } a_1, \cdots, a_n \in \mathbb{F} \implies a_1 = \cdots = a_n = 0$$

This looks great! If you are unsure about what LaTeX code should be for a given symbol, search online! Here is the link.

3.4 Another example: Proof

3.4.1 Before the example

Notice that we can type the summation in LaTeX like this $\sum_{i=1}^{n} a_i v_i$. But this is different from what we expected. We expected the following.

$$\sum_{i=1}^{n} a_i v_i$$

This is because of the different display styles in a paragraph or as an equation. We can fix it as follow: $\displaystyle\sum_{i=1}^{n} a_i v_i$ is what we wanted!
However, it might be annoying to keep using that displaystyle command many times during the proof. We can define a new command to save us some times. Once we define the new command, this is what we wanted $\displaystyle\sum_{i=1}^{n} a_i v_i$

3.4.2 Now the example

A set of vectors $\{v_1, \cdots, v_n\}$ in V is linearly dependent, if at least one of those vectors can be written as a linear combination of the other vectors. Prove that if a set is linearly dependent by the original definition, then it is linearly dependent by this equivalent definition.
This is a similar question to what we have seen in the tutorial. Let's try to prove it together!

Proof. Let $S = \{v_1, \cdots, v_n\}$ be a set of vectors in V.
WTS: If S is linearly dependent by the original definition, then it is linearly dependent by the equivalent definition.
Assume S is linearly dependent by the original definition, that is

$$a_1 v_1 + \cdots + a_n v_n = 0 \text{ for some } a_1, \cdots, a_n \in \mathbb{F}$$

and $\exists i \in \{1, \cdots, n\}$, such that $a_i \neq 0$.
Therefore,

$$a_i v_i = -\sum_{j=1, j\neq i}^{n} a_j v_j \tag{1}$$

$$= \sum_{j=1, j\neq i}^{n} (-a_j) v_j \tag{2}$$

Since $a_i \neq 0$, a_i^{-1} exists in $\mathbb{F}$. Therefore, $v_i = \displaystyle\sum_{j=1, j\neq i}^{n} (-a_j a_i^{-1}) v_j$ by equation (2) above, which is a linear combination of $v_1, \cdots, v_{i-1}, v_{i+1}, \cdots, v_n$. Therefore v_i is a linear combination of the others, and hence S is linearly independent.
$\square$

3.5 Matrices

Matrices can be typed using LaTeX as follow with the amsmath package. Remember it has to be in the math mode. For example, $\begin{pmatrix} x_1 \\ x_2 \\ x_3 \end{pmatrix}$ gives a 3×1 matrix, and $\begin{pmatrix} x_{11} & x_{12} \\ x_{21} & x_{22} \\ x_{31} & x_{33} \end{pmatrix}$ gives a 3×2 matrix.

4 More examples

Remember, every vector space is equipped with two operations $+$ and $\cdot$. In the definitions, there are quantifiers for-all $\forall$ and there-exists $\exists$.
Besides, we have seen the followings in set theory:

- The empty set $\emptyset$
- Subset $\subseteq$ and proper subset $\subset$
- Belongs to $\in$ and not belongs to $\notin$
- Intersection $\cap$
- Union $\cup$

Lastly, we have seen some Greek alphabets, such as $\alpha, \beta, \delta, \phi, \psi$.