Musa Al'Khwarizmi
CS 3141: Prof. Kamil's Algorithm Analysis
January 5, 2021

Homework Class Test

Question 1. What is this document?

This is a demonstration of my homework LaTeX class. It is an extension of the `amsart` and should have all of its functionality.

Question 2. What preamble commands does the class have?

We have all that AMS article has, the preamble for this document had:

```
...
\author{Musa Al`Khwarizmi}
\class{CS 3141: Prof. Kamil's Algorithm Analysis}
\date{\today}
\title{Homework Class Test}
\address{Bayt El-Hikmah}
...
```

Question 3. What symbol shortcuts does it have?

It has the symbols shown in table 1,

Macro	Symbol	Macro	Symbol
`\C`	$\mathbb{C}$	`\floor{\frac{x}{2}}`	$\left\lfloor \frac{x}{2} \right\rfloor$
`\R`	$\mathbb{R}$	`\ceil{\frac{x}{2}}`	$\left\lceil \frac{x}{2} \right\rceil$
`\Q`	$\mathbb{Q}$	`\near{\frac{x}{2}}`	$\left\lfloor \frac{x}{2} \right\rceil$
`\Z`	$\mathbb{Z}$	`\arr{\frac{x}{2}}`	$\left\langle \frac{x}{2} \right\rangle$
`\N`	$\mathbb{N}$	`\paren{\frac{x}{2}}`	$\left(\frac{x}{2} \right)$
`\P`	$\mathbb{P}$	`\brk{\frac{x}{2}}`	$\left[\frac{x}{2} \right]$
`\F`	$\mathbb{F}$	`\curl{\frac{x}{2}}`	$\left\{ \frac{x}{2} \right\}$
`\GF, \GF[7]`	$\mathbb{F}_2, \mathbb{F}_7$	`\abs{\frac{x}{2}}`	$\left\lvert \frac{x}{2} \right\rvert$
`\0`	$\varnothing$	`\modulo[7]`	$\mathbb{Z}/7\mathbb{Z}$
`\O(n)`	$\mathcal{O}(n)$	`\vec{v}`	$\vec{v}$
`\?`	$\stackrel{?}{=}$	`\bijective`	$\rightarrowtail\!\!\!\!\rightarrow$
`\is`	$\equiv$	`\surjective`	$\twoheadrightarrow$
`\al`	α	`\injective`	$\hookrightarrow$
`\ep`	ε	`\Ra`	$\Rightarrow$
`\phi`	φ	`\ra`	$\rightarrow$
`\p`	∂	`\derivative[g]{f}`	$\frac{\mathrm{d}f}{\mathrm{d}g}$
`\D`	d	`\derivative{\zeta}`	$\frac{\mathrm{d}\zeta}{\mathrm{d}x}$

TABLE 1. Symbols table.

The commands that have twin delimiters expand according to their input,

$$\lfloor x \rfloor, \lceil y \rceil, \lfloor z \rceil, \langle x, y, z \rangle, \left\lfloor \frac{x}{2} \right\rfloor < \frac{x}{2} < \left\lceil \frac{x}{2} \right\rceil, \left\lfloor \frac{x}{2} \right\rceil, \left\langle \frac{x}{2}, \frac{x}{3}, \frac{x}{4} \right\rangle, \left(\frac{x}{2}, \frac{x}{3}, \frac{x}{4} \right), \left[\frac{x}{2}, \frac{x}{3}, \frac{x}{4} \right], \left\{ \frac{x}{2}, \frac{x}{3}, \frac{x}{4} \right\}, \left\lvert \frac{x}{2} \right\rvert$$

Question 4. Are pictures still a pain though?

No! We have: `\fig[<w>]{<path/f0.png>, ... , <path/fn.png>}{<caption>}{<label>}}`.

Or, you can set the path to all the images once with `\graphicspath{{path}}` in the preamble and then you can do, `\fig[<w>]{<f0.png>, <f1.png>, <f2.png>, ...}{<caption>}{<label>}}`

We did `\graphicspath{{../media/}}` with

`\fig[0.2]{khwarizmi.png, kitab.jpg, page.png}{Al`Khwarizmi}{trio}}` to get the figure 1.

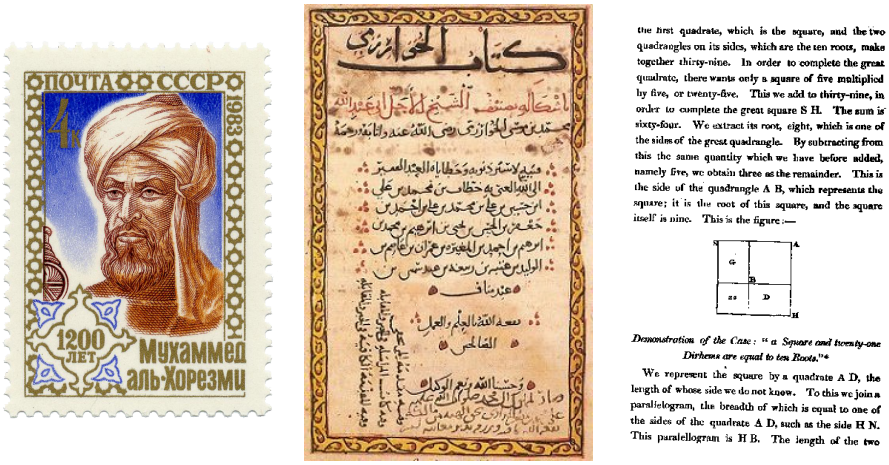

FIGURE 1. Al'Khwarizmi

Question 5. We have all AMS article environments such as proof. Prove that $\exists(x, y) \in \mathbb{Z}$ such that $x + y = 4$.

Proof. Four is the sum of two integers.

$1, 3 \in \mathbb{Z}$ and $1 + 3 = 4$.

QUOD ERAT DEM■

Note the fancy *Q.E.D* symbol.

Question 6. To show citations and references to custom labels: What is the cardinality of $\mathbb{N}$?

It is $\aleph_0$ [1] (`\cite{arlinghaus1996part}`). See also question IX (`\ref{custom-index}`).

Question 7. What headlines does this class have?

We have the following hierarchy of headlines:

`\question[<custom-ind>]` > `\section{<name>}` > `\subsection{<name>}` > `\subsubsection{<name>}`.

Since we inherited all the section commands from AMS article, we can also use their stared variants. We demonstrate these bellow,

7.1. Section

7.1.1. Subsection.

7.1.2. Subsection.

7.2. Another Section

7.2.1. Subsection.

Subsubsection. This is a started section.

7.2.1.1. *Subsubsection.* We end here.

Question 8. Are all headlines preceded by the question number they are under?
Yes, they are preceded by the index of question they are under.

8.1. Section

8.1.1. **Subsection.**

8.2. Another Section

8.2.1. **Subsection.**

8.2.1.1. *Subsubsection.*

8.2.1.2. *Subsubsection.* We end here.

Question IX. Is the cardinality of Naturals and Reals the same because they are both infinite?
No, the cardinality of $\mathbb{R}$ is greater because they are also un-listable (uncountable). See also question 6.

Question 9. What is a complete minimal example?
In listing 1 we show a complete document using `homework.cls`,

```
\documentclass{homework}
\author{Musa Al`Khwarizmi}
\class{CS 3141: Prof. Kamil's Algorithm Analysis}
\date{\today}
\title{Minimal Complete Document}
\address{Bayt El-Hikmah}

\begin{document} \maketitle

\question Write down sets in order of containment.

We pretend that equivalence classes are just numbers.
\[
  \C \supset \R \supset \Q \supset \Z \supset \N \supset
  \P \supset (\GF[7] = \modulo[7])  \supset \{\nil\}
\]

\question Give an example element of $\O(n)$.

Take $11n \in \O(n)$.

\question Find roots of $x^2- 8x = 9$.

We proceed by factoring,
\begin{align*}
  x^2- 8x - 9          & = 9-9          &  & \text{Subtract 9 on both sides.}          \\
  x^2- x + 9x - 9      & = 0            &  & \text{Breaking the middle term.}          \\
  x(x - 1) + 9(x - 1) & = 0            &  & \text{Pulling out common factors.}        \\
  (x - 1)(x + 9)       & = 0            &  & \text{Pulling out common } (x - 1).       \\
  x                    & \in \{1, -9\} &  & f(x)g(x) = 0 \Ra f(x) = 0 \vee g(x) = 0. \\
\end{align*}

\question Show P $\?$ NP.

Let P be zero... Sorry.
\end{document}
```

Listing 1. Complete LaTeX Document

This will get you a document looking like the one in figure 2.

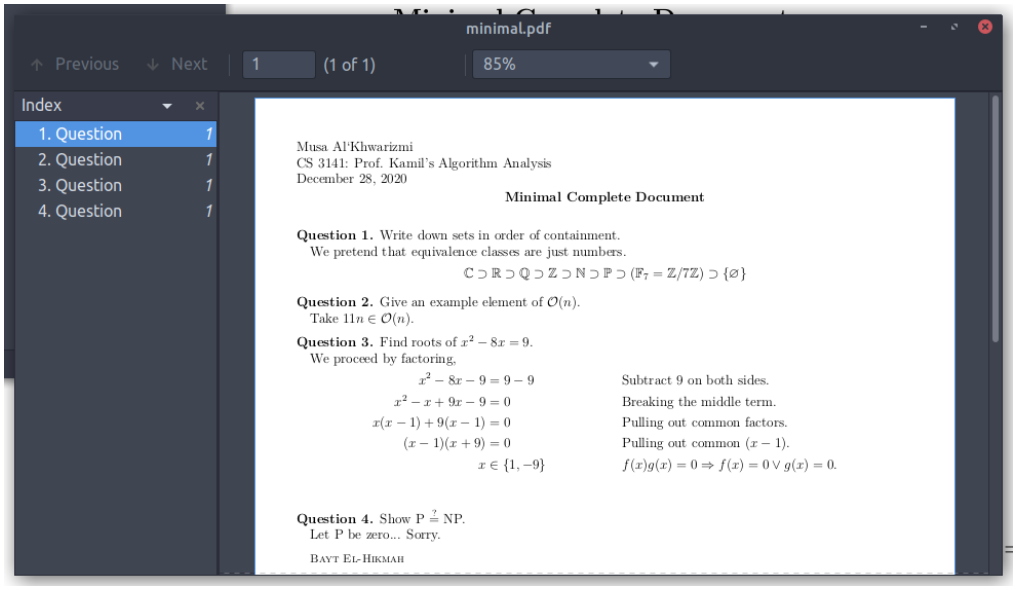

FIGURE 2. Out document from listing 1.

Finally, bellow are the two questions that use the `bonus` environment. Which is really just the residue of the old times when I started with LaTeX and had a separate environment to typset extra-credit questions. I no longer use it because I mostly just end up utilising the optional argument of the question command. But,H here it is regardless!

Question (Bonus) 1. State chain rule.
Chain Rule:

$$\zeta(x) = f(g(x)) \qquad \text{then according to the chain rule:} \qquad \frac{\mathrm{d}\,\zeta}{\mathrm{d}\,x} = \frac{\mathrm{d}\,f}{\mathrm{d}\,g} \times \frac{\mathrm{d}\,g}{\mathrm{d}\,x}$$

Question (Bonus) 2. Euclidean Algorithm
You may write code as in listing 2,

```
1  def gcd(x, y):  # x > y
2    x0, x1, y0, y1 = 1, 0, 0, 1
3    while (y > 0):
4      print('\\gcd(%d, %def) &: %d &&= ' % (x, y, x), end='')
5      q, r = divmod(x, y)
6      # print('%d \\times %d + %d &&\\quad' % (q, y, r), end='')
7      # print('[%d, %d] - %d[%d, %d] = ' % (x0, x1, q, y0, y1), end='')
8      x, y = y, r
9      x0, x1, y0, y1 = y0, y1, x0 - q * y0, x1 - q * y1
10     # print('[%d, %d] \\\\' % (y0, y1))
11   return x, x0, x1
```

LISTING 2. Euclidean Algorithm for Greatest Common Factor

References

[1] Sandra Lach Arlinghaus and SL Arlinghaus. Part ii. elements of spatial planning: Theory. merging maps: Node labeling strategies. *Unknown*, 1996.

Bayt El-Hikmah