

Is There Enough Potentially Available Renewable Energy to Meet The Needs of the Current Population of the Planet Earth?

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An article usually includes an abstract, a concise summary of the work covered at length in the main body of the article.

I. BRIEF LATEX TUTORIAL

Most of writing a LATEX document is just plain text, as you can see on the left of the screen. If you type some text, you'll see the website will "compile" it for you if you wait a short while, and it'll appear in the preview on the right.

LATEX only sees a paragraph when there's a completely blank line between the two paragraphs, so make sure you always put in your paragraphs like that. Splitting the lines like I've done in the tutorial is not at all necessary, it can just be easier to work with for some people.

A. Writing Commands

If you look at the "source" of the document, on the left, you'll see that I've written things which aren't text. Anything that begins with a backslash, \, is a LATEX command, and they appear in green in the source. The most common ones we'll use are going to be \section{Title}, \subsection{Title}, and \label{type:name}. You can see how I've split the file into sections, and how they appear in the document. I've also given each section a label, which will become more important later on.

There are lots of LATEX commands—far more than anyone actually needs to know. Happily, you can find them all by googling, or you can ask me, I guess.

B. Writing Equations

LATEX is really good at typesetting equations prettily, but unfortunately it can look pretty incomprehensible in the source if you're not sure of how the syntax works.

First off, we can write simple inline equations by wrapping the equation in dollar signs, so \$a+b=c\$ produces $a + b = c$. This is good for simple things, like Pythagoras' theorem, $a^2 + b^2 = c^2$ makes $a^2 + b^2 = c^2$. As you can see, I used ^ to make a power. Likewise, I can use _ to make a subscript, as in v_i, making v_i .

Since we use a lot of Greek letters in physics, it's easy to put these in too. For each letter there is a LATEX command, of the style \letter, where "letter" is the name. So \phi produces ϕ , \alpha makes α , and \zeta makes ζ . You can also make the capital version of these by mak-

ing the first letter of the commands a capital letter, such as \Delta makes Δ , and so on.

We can also write big equations, and LATEX will automatically number them for us too. To do this, we wrap the equation in \begin{equation} and \end{equation}. We can also give an equation a label, so we can reference it later. Here's a big integral equation, then I'll break down the various commands in it

$$\int \frac{2x+1}{x^2+x} dx = \ln(x^2+x) + c. \quad (1)$$

Here, \int makes the integral sign. \frac{top}{bottom} makes the fraction, and you can see where the top and bottom parts go. \dd makes an upright "d", like in a differentiation. \ln makes the log, naturally (lol). Brackets will work like normal in LATEX. As you can see, the equation also got given a number.

Equations should be a part of the text, so if they finish a paragraph, like the previous one, they get an extra line between them and the next sentence. They should always have a punctuation mark at the end of them, too, whether that's a full stop or a comma.

If you need more maths commands, the list on <http://www.thestudentroom.co.uk/wiki/LaTeX> is pretty good, or there's a wikibook somewhere around which is also excellent.

C. Referencing Things

Aside from doing equations prettily, this is one of the most powerful bits of LATEX. If you look in the text, you'll see \label{} every now and again. This is important, because it lets us reference any previous section, equation, table or figure. We haven't put any of the last two in yet, but I'll put up a demo of that at some point too.

Say I want to mention what I talked about in the section on writing commands. In LATEX I don't need to know the number of the section, I can just type \cref{sec:writing_commands} to produce the text "section IA". Likewise, I can reference eq. (1) using \cref{eq:big_integral}, and so on. This really makes it clear how important it is to write good labels. A label should uniquely reference the equation or section (or whatever), and shouldn't depend on order. If I added

another section or equation before the ones I numbered, the references would also update.

Try changing the order of the following two equations in the source and let the document update to see the references change:

$$pV = nRT, \quad (2)$$

$$n_1 \sin \theta_1 = n_2 \sin \theta_2. \quad (3)$$

The ideal gas law is eq. (2), and Snell's law is eq. (3).

D. Citing Other Works

Referencing internally in the document is very easy, but L^AT_EX also makes it very easy to manage a bibliography too. Click "Project" at the top of the webpage to see all of the files in the project. I've made two files to start with, `main.tex` which is this file, and `renewables.bib` which is a bibliography file. I've put a couple of references in that file to show how to format it for a book, and for an article.

Like equations and sections, citations also take a label. This label comes immediately after the `@article` or `@book` declaration in the bibliography. For these, you should use the surname of the lead author, followed by the last two digits of the year that the work was published in. This makes it easy to remember the names of the papers to reference them.

I may have made up some of the details of the Michelson paper, but oh well. I can cite them using the `\cite{label}` command, so I can talk about the book by MacKay [1] using `\cite{mackay09}`, or the totally irrelevant paper by Michelson [2] using `\cite{michelson81}`. Notice how the references have been given a number corresponding to the full references at the end of the document.

The fact that many countries across the globe are still developing has a potentially large impact on the total energy consumption of Earth. Indeed, it is estimated that developing countries will consume 65 (per cent) of the world's energy by 2040. (reference <http://www.theatlantic.com/technology/archive/2013/12/heres-why-developing-countries-will-consume-65-of-the-worlds-energy-by-2040/282006/>) Indeed the energy consumption of developing countries is predicted to grow at a 2.2 (percent) annual rate, whereas developed countries are only expected to increase their consumption by 0.5 (per cent) per year, which is approximately inline with

population expansion. Indeed, most of the growth of energy demand if forecast to come from the developing world, which consumed more units of energy than the developed world in 2007. The bulk of the growth in energy consumption, fossil fuel use and greenhouse gas emissions is expected to be attributable to countries like China and India, who rely on coal and other fossil fuels to generate electricity. Much of the increase in the developing world's consumption can be traced back to population growth. However the increase is exacerbated by the fact that energy consumption per person is also set to increase in developing countries. Increased incomes among the poor and near-poor populations leads to people coming out of poverty and joining the middle classes. People then desire to buy cars, climate control systems for building interiors and other large devices, such as refrigerators. These new goods require energy to use, maintain and manufacture. Due to this, the energy consumption per capita is predicted to increase by 46 (per cent) in the developing world over the next three decades. In comparison, the energy use per capita in developed nations is expected to remain approximately constant, as the majority of the population are already in the middle classes, and so already own cars and the other devices previously mentioned. Indeed, in India, 600,000 new vehicles were sold in 2003, and the numbers being sold are continuing to increase. Similarly the numbers of air conditioning units sold in countries like India, China and Brazil is also on the rise. The increasing wealth in developing countries is likely to have a large contribution to the demand for energy in the near future because a large share of the world's population has yet to go through this "asset acquiring" transition. It is important to remember that many of the current forecasts for future energy demands in developing countries may be understated, as forecasts cannot accurately capture the dramatic increase in the demand that is associated with poverty reduction in the developing world. It is equally difficult to model the effects of population growth and the distribution of economic wealth. However, not all of this extra energy demand will be met through the burning of non-renewable sources. Renewable energy is a growing area of development in China, and indeed, China has announced ambitious renewable energy goals, including producing 49,000 MW of power using new solar and hydroelectric equipment. It is also important to consider the fact that future energy use may very well be more efficient than it is currently.

[1] D. MacKay, *Sustainable Energy Without the Hot Air* (UIT Cambridge, 2009).

[2] M. Michelson, Am. J. Sci. **26**, 21 (1881).