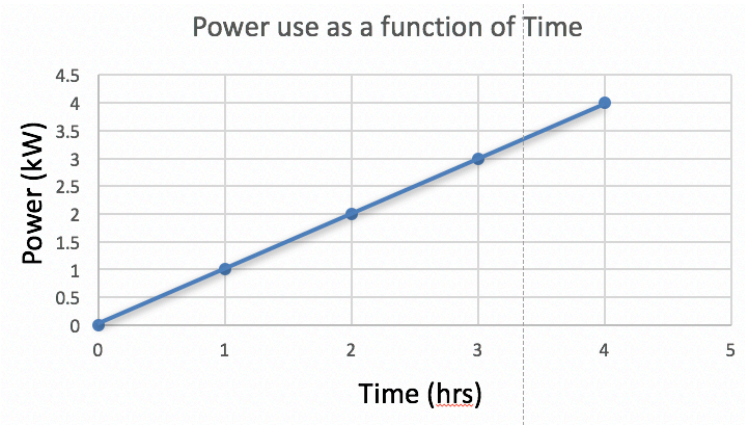
Big Exam #1: PHYS 320

In Midterms, you are allowed a calculator and notes with 50 bits of information. However, in this big exam, please work out your answers without a calculator. I will be looking for proper canceling of units. Precision is not important.

It's important to note that this "test" had several purposes: to get to know each other through discussion, to practice calculations, review/refresh issues, and to help you get to know how I want questions answered. It should not reflect if you are good at this, or smart or all-together a good person. The few students in this class who had me for physics 141 will tell you that almost everyone "failed" the first "Big Exam!" they had. My physics students largely found Big Exams beneficial and this is the first PSC 320 Big Exam! So please bear with me as we learn together.

1) Please do the following calculation, showing reasoning
   a) How many Joules are in a kWh (a kiloWatt-hour)?
   b) How long would a kWh light a room with a 10 W of LED lighting?

It's absolute imperative that you start this kind of question with the formula P = E/t, where "E" could be "dE" (for change in energy) or "Work", and "t" could be "dt" for change in time. You can rewrite this formula as E = P*t. This is the most important formula for the class and we will use it again (and again and again).
If we look at "E = P*t" we can see that a kW*hr is units of power * time, so this is an energy. This is not the same as a kW/hr… and this is a *VERY* common mix up. Let's say you had 40 light bulbs that were each 100 W, and you started with them all off, but turned an additional one on every 6 minutes. after 1 hr, you'd be drawing 1000 W, after 3 hours, you'd be drawing 3 kW. Your power use would increase at a rate of 1 **kW/hr** as shown by the slope of the graph at right. This 1 kW/hr is how fast your power use *increases*. The average power consumption during the 4 hrs is 2 kW. Thus, the total *energy* you use is: $E = P_{(ave)}*t = 2\text{ kW} * 4\text{ hrs} = 8\text{ kW*hr}$.



this is what PG&E would charge you for. At a rate of \$0.15 / kWhr, you would pay
Total bill = (8 kW*hr)*(\$0.15 / kWhr) = \$1.20.
Show yourself how you would cancel the kWhr to get the units right. So "kW/hr" would be how fast you increase your power use; and kW*hr is electrical energy used over time.

Thomas had a great idea: he said that 1 kW*hr means you could use a kW for one hour, so you could use 100 W for 10 hours, you could use 10 Watts for 100 hrs, you could use 1 W for 1000 hrs, etc.

We will practice this more.

2) You visit a friend in West Virginia and ride her electric scooter. You accelerate her scooter and then come to a stop by applying the breaks. Please make an energy diagram showing the energy conversions for your scooter ride. Then extend the flow diagram in both directions so that you begin from the primary energy source and end with the ultimate energy sink. It is worth noting that in West Virginia, electricity is generated by coal: coal is burned. It boils water. The pressure turns a fan. The fan turns a generator to generate electricity.

We know that there are three sources of energy (power) to the earth, so we have to pick between the sun, the rotational kinetic energy of the earth spinning (tides), and nuclear energy (including geothermal). Maybe we don't know that coal comes from prehistoric plants (hence "fossil" fuels) but we will talk more about this later.

We also know that unless we store energy in a battery or spring that lasts eternity, then our energy transitions almost all end in thermal energy that is radiated into space.
I asked many people for more description. It's not enough to say that the electricity made the scooter move fast. You have to identify the electrical energy (from the grid) to the chemical potential energy (in the battery) to the kinetic energy (in the motion of the scooter).

Question #3 is on the other side

3) This class is about *ENERGY*, so why are we talking about *POVERTY* and all the related concepts such as life expectancy, per capita GDP, and fecundity (number of babies per woman)?
   This question was badly stated, I should have asked at the end, "In short, what does the study of energy have to do with the societal concerns of poverty? Please give an example"

There are many good answers and examples, but I think that there are a few basic concepts that should be included:

1) **Energy poverty is poverty**: either because you generate wealth through energy conversion, or because converting energy requires machines, which cost money. Thus, energy use is correlated with societal well-being.
2) **Energy use has environmental impact**: either because of resource extraction or emissions, our energy conversions often affect the environment. This affects people differently. Here is the issue of *Environmental Justice (EJ)*, while the rich consume the vast majority of the energy, it is the poor that disproportionately suffer from environmental degradation.
3) **Our demographics are changing**: Presently, the majority of the world is considered poor, but this is changing rapidly. The world's poor can't develop the same way the industrial countries did because fossil fuels are no longer easy to get (they've been used up). However, if they did develop in this fashion, the environmental impact with the larger numbers would be catastrophic. This provides a strong incentive to change… for all of us. Regardless, we are changing.
4) **There one more thing you could add if you are motivated to help others (but I'm not saying you have to be)**: If we value sustainability for all, then we would be motivated to support those struggling with poverty. Because of #1 above, access to energy is a large part of that.