Problem Set #1: PHYS 320 The World: Energy Units & Conversions, Global Energy Use
Due Monday, Jan 13 in class.

Please do your work without a calculator, and estimate your answers best you can. You can check with a calculator afterwards if you really want to. Usually if you are within 20%, that is fine. Please start a list of constants and equations that you find helpful – this can be your notes for exams. Please expect that your answers will differ because you will estimate differently, and you will have to look up values online – and may find that you access different answers from other students.

Proper canceling of units. We will be learning how to properly cancel units, and work problems out with a pencil (or pen) to make sure that units work… this is VERY important because the world conspires to make life difficult with units that vary from Watts and meters to Horse Power and miles. Please show all units all the way through a problem with proper canceling.

1) Go to Gapminder!
   a) Print out a Graph from Gapminder Make a graph of per capita CO_2 emissions versus per capita income and follow (by clicking on the icon or checking the box by the country on the list at right) the USA, China, and one or two other countries that you are interested in. What do you learn? You can find Gapminder here: https://www.gapminder.org/, but in order to access the information, you have to scroll down to "Refresh your world" or go here: https://www.gapminder.org/tools/#$chart-type=bubbles How did these values change in time? Is the growth linear or more or less than linear? Is it close to exponential? Or do you see that there is a distinct change at one point in time?
   b) How well is per capita CO_2 emission correlated with GDP/capita? Does one *generally* increase with the other? Does one *always* increase with the other? Might it be a good idea to explore what might have caused the two to *not* be correlated?
   c) If you answered in a) above that there was a distinct change at some point, see if you can correlate any interesting features in the graph with the corresponding global events such as a war, a depression or recession; or change in government.

2) Make another graph on Gapminder of something versus something else that you find interesting.
   a) Please follow the graph for the USA, China and two other countries. Print out this graph.
   b) Please explain why the graph looks the way it does. That is, given the quantities you chose, how would you expect one to change when the other changes?
   c) Please consider how any historical events or trends are reflected in features on the graphs.

3) The definition of a Watt is a Joule per second. Or power is rate of change of energy:
   $P = \Delta E/\Delta t$ = Work/Δt, or $\Delta E = P*\Delta t$ [yes, this is awful: W stands for work, which is energy and has units of Joules, but W is also the symbol for Watt, the unit of power, which is the same of J/s.]. Consequently, not only is 1W = 1J/s, but 1J = W*s.
   a) Please prove this second relationship (J = W*s) to yourself by canceling units.
   b) How many Joules are in a kWh (a kiloWatt-hour)? This would be the energy used in order to power a kW device (like a hair drier) for one hour.
   c) How long would a kWh light a room with a:
      a) 100 W incandescent light bulb.
      b) 30 W compact fluorescent bulb.
      c) 10 W of LED (Light Emitting Diode) bulbs.
      ****Note that each of these lightbulbs will each provide the same amount of light. The extra power for a) and b) is released as heat.
   d) How much would a kWh change the temperature of my hot tub? ~ 1 m^3 or about 1 Tonne.

e) How much does the average Californian pay for a kWh of electricity? Many questions in this class will ask you things we haven't covered and will require you to look up.
f) How big is a kWh battery?... its mass, its dimensions? As above, I encourage you to go shopping for batteries on the internet and see what you find.

4) Remember the energy flow diagram from the "dropping the rock" video? Please consider the following process: You like to ride your electric scooter, and are pleased to charge it from the solar panel on your roof. You accelerate your 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 (deep space).

5) Consider one of your favorite energy conversion processes. Please make an energy flow diagram as in #4 above for this process. I request that this process be as unique as possible from that of #4 and the "dropping the rock" process.

From our activity, please do the following question without a calculator. You may need to use scientific notation if the numbers are big.

6) Make a calorimeter: Make a calorimeter by burning a candle and heating some water with it! The goal is to measure the input and output energy so you can calculate the efficiency of the energy conversion process.

a) Make a drawing of your experiment
b) Draw the energy conversion flow chart for your calorimeter.
c) Show the calculation and explain how you got the energy density
d) Show a calculation and explain how you got the power output of the candle.
e) Look up the energy density of wax… is it close to what you measured/calculated? About how efficient was your calorimeter?