Problem Set #1: PHYS 320 The World: Energy Units & Conversions, Global Energy Use
Due Wednesday, Jan 18 in class.

Please do your work without a calculator, and estimate your answers best you can. You can check with a calculator. Usually if you are within 20%, that is fine. Please start a list of constants and equations – possibly keep them on a dedicated Excel Spreadsheet. Because you will need to look up values on the web and make some assumptions and estimates, different people will have answers that differ.

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, to Tons (of ice per day). Please show all units all the way through a problem with proper canceling.

1) Make a graph of per capita CO_2 emissions versus per capita income and follow (by click 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?
   a) How did these values change in time? Do they change kind of exponentially or, more or less linear in time, or greater than linear, or less, or how does the general behavior change at some point?
   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) 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 the national leader.

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 one or two other countries. Print out this graph.
   b) Please consider how the x and y axis should be correlated and if they exhibit the expected behavior.
   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: $P = \Delta E/\Delta t = W/\Delta t$, 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 to yourself by canceling units.
   b) How many Joules are in a kWh (a kiloWatt-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 light the room about the same, but a) and b) heat the room much more.
   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?
   f) How big is a kWh battery?... its mass, its dimensions?

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. Then you visit a friend in West Virginia and ride her electric scooter. You learn that her electricity comes from their grid that is largely supported by coal-fired electricity generation. 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.

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 two questions without a calculator. You may need to use scientific notation if the numbers are big.

6) What is the rate of energy consumption of your car?:
   a) How long does it take you to burn a gallon of gas while driving?
   b) How many joules of energy are in a gallon of gas?
   c) What rate of energy consumption does this correspond to?
   d) Make an energy diagram of this energy transformation process.

7) 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) Draw the energy conversion flow chart for your calorimeter.
b) Measure the input energy and the output energy
c) Measure the input power and the output power
d) Estimate the efficiency of the energy conversion in your calorimeter
e) How could you make your calorimeter more efficient – that is it would lose less energy?
f) If you had enough time, please use your calorimeter of known efficiency to measure the energy density (caloric content) of some food – like nuts.