PHYS 310 S15 Problem Set #3
Due at the beginning of class, Monday, April 20

1) Remember our Bugatti Veyron? http://www.youtube.com/watch?v=LO0PgyPWE3o Please reconsider the subject of efficiency:
   a) What was the efficiency you calculated? This is called the "first law efficiency" because it follows directly from the first law of thermal physics. This is also of course the *actual* efficiency of the vehicle.
   b) What is the maximum possible efficiency you could hope for given the extremes of temperature between ambient outside temperature and the hottest hot of the combustion (you'll have to look this up… but I wasn't able to find it for a Veyron. You could look it up for the general Otto Cycle.)
   c) What portion of this maximum theoretical efficiency did you achieve? This portion is called the "second law efficiency" because the Carnot Efficiency comes from adhering the second law of thermal physics.
   d) Even a perfect, frictionless Otto Cycle doesn't achieve the first law efficiency. Please see: http://web.mit.edu/16.unified/www/SPRING/propulsion/notes/node25.html and investigate the efficiency of the Otto Cycle – what is the key factor? Why are diesel engines a little more efficient than the Otto Cycle? Well, there are a few reasons we will investigate later, but please find one of them now.
   e) What is the second law efficiency for a perfect Otto Cycle (achieving perfect Otto Cycle efficiency for the temperatures and compression ratios you find)?
   f) What portion of the maximum possible Otto Cycle efficiency does your Veyron actually achieve?

2) Coal Power Production

Coal and natural gas are the two predominant forms of fossil fuels used for generating electricity in the world. Compared to the NGCC, coal is a worse polluter on two levels – criteria pollutants (like toxins), and in terms of CO_2 production.
   a) What does NGCC stand for?
   b) Why does burning coal emit more toxins into the atmosphere and what are some of these toxins?
   c) For the same amount of electricity, coal emits more CO_2 than the most efficient Natural Gas electricity generation by what factor?
   d) Why is it that Coal Electricity emits more CO_2 than natural gas electricity generation? Please give two reasons.
   e) What portion of the world's coal does the US consume? China? What portion of the world's NG does the US consume? China?

3) Remember your friend who left his 100 W incandescent light on for a year? This choice resulted in the emission of how much mass of CO_2 into the atmosphere...:
   a) if the electricity was generated with a new NGCC power plant.
   b) the electricity was generated with an old coal-fired Rankin Cycle facility.

   This choice required the combustion of what mass of fuel if:
   c) if the electricity was generated with a new NGCC power plant.
   d) the electricity was generated with an old coal-fired Rankin Cycle facility.

4) Running a Natural Gas Combined Cycle

Let's say you're in charge of a NGCC for Southern LA. You control the flow of NG to the Brayton Cycle turbine and you can monitor the (a) electrical current, (b) the torque (how hard the turbine has to push the generator to keep it going), (c) the spinning frequency of the turbine, and the (d) output voltage. At 5:30 PM, everyone gets home and turns on their electrical appliances – especially air conditioners..

a) When this happens, what do you notice about measurements in (a) – (d) above?
b) How do you respond with the flow of NG to the Brayton Cycle Turbine?
c) After your action, how do measurements (a) – (d) change?
d) After your action, how do measurements (a) – (b) compare to how they were before everyone came home?

5) Transmission

Why do we need Transformers?

a) Please explain how transformers reduce transmission losses, and include consideration of High Voltage, AC/DC, and resistive heat losses in a wire.

Let's say you're on a task force to address the power loss to Bakersfield from Diablo. The power lines were made a long time ago and since then, Bakersfield's demand for electricity during peak hours has doubled.

b) If the power use has doubled, by what factor will the amount of heat loss in the cables increase?
c) On extra hot days, there will be an extra thermal load on the wires. What problem occurs when the wires heat up? How would this change the transmission losses?
d) Long wires have considerable inductance and capacitance. How does this affect heating losees?
e) You find a way to increase the transmission voltage by a factor of 5. By what factor will this change the transmission losses?

Please read more about what transmission lines are made of at
http://en.wikipedia.org/wiki/Electric_power_transmission

6) DH's book: 12.1 Dutch Sun
7) DH's book: 12.6 gain and loss in Chicago windows
8) DH's book: 12.14 Solar hot water
9) 12.15 South facing glass