1. Read section 2 of the 120B notes.

2. A schedule 40, 2 inch steel pipe (Inner diameter 2.067 inches, wall thickness 0.154 inches) carrying steam is lagged (insulated) with 2 inches of 85% magnesia covered with 2 inches of cork. Compute the heat loss per hour per foot if the inner surface of the pipe is 250F and the outer surface of the cork is 90 F. Steel has a thermal conductivity of 26.1 BTU/(hr ft F), magnesia 0.04 BTU/(hr ft F) and cork 0.03 BTU/(hr ft F). Neglect conduction. In doing the necessary conversions between inches and feet, ponder why metric units make so much more sense.

3. Nuclear fuel pellets consist of a spherical core of radius $R_1$ of fissionable material of thermal conductivity $k_n$ that generates an energy per volume $S$. To more easily handle this radioactive material, each pellet is encased in aluminum of thermal conductivity $k_a$ and outer radius $R_2$. No heat is generated within the aluminum. The entire fuel pellets are then immersed in a fluid of temperature $T_f$ and heat transfer coefficient $h$.
   a. Using shell balances for energy, write the steady state heat conduction equations for the nuclear core and aluminum shell.
   b. Write the boundary conditions for the inner sphere ($R_1$) and the outer sphere ($R_2$). Write a short explanation of each.
   c. Solve for the temperature distribution for the core and the shell. What is the maximum temperature of the core and the outer shell?

4. The Alaska pipeline runs 800 miles (1280 km), from the arctic ocean to Valdez, Alaska. The pipe itself is 48 inches (122 cm) in diameter, with 1/2 inch (1.27 cm) thick steel. It is insulated with a 4 inch (10 cm) layer of fiberglass insulation ($k = .04 W/mK$), and the oil is generally pumped at 145°F, in air that can be −40°F. Assume the pipe to have a heat transfer coefficient in air $h = 24 W/m^2K$ (assuming a 1 mm boundary layer).
   a. Compute the energy loss per foot per time due to heat transfer. Compute the total energy loss for the entire pipeline. Compute the general formulas first, then plug in numbers.
   b. Where does most of the temperature drop occur? Compare the insulating properties of the steel pipe, the fiberglass insulation, and the convection through the air. Where is the resistance to heat transfer the highest?
   c. Does the system exceed the requirement set by the critical insulation thickness, in order that the insulation actually help?

5. The Squires Diet™, which is sure to make me rich if I can just figure out a way to charge for it. Your body is constantly maintained at 98.6 °F, or 37C. You burn food to maintain this temperature. Rather than scrimp on food, or eat healthy, or – gasp – exercise, why not just make your thermostat work a little harder? Here’s the plan: fill your bathtub with ice water (0 C), then lay down in it for one half hour per day, while watching Judge Judy on TV. Assume Newton’s law of cooling (heat transfer coefficient $h \approx 500 W/m^2 C$, which I got assuming a 1 mm boundary layer), and that your body has about 2 m² of surface area. How much Joules of energy do you lose to the ice water during this time? Convert this energy to kilocalories (which is a food ‘calorie’). Since a Big Mac, super-size fries, and diet coke run about 1200 ‘calories’ (kcal), how many such value meals can you now eat without gaining weight?
   P.S. do not actually try this.