Physics 216 HW Ch20&21 due at the beginning of class 4/18/2018.

To receive full credit:

- **clearly show your reasoning** (including any necessary calculations),
- **indicate your final answer in an unambiguous way** (such as by circling or underlining it).
- **Round your answers appropriately**

1. Ch 21: For problem 35, draw (carefully!) the pV diagram for the cycle described. Clearly label axes and also label the paths on the diagram by the numbers in the figure for the problem AND by what kind of process is involved (e.g. isothermal, etc).
2. For several reasons, electric utility companies are motivated to deliver electric power at fairly steady amounts around the clock. Unfortunately, consumers, who like to sleep, tend to use more electric power during the day. To "even out" the demand, power companies offer electric power at lower rates during the night. You are building manager for a large office building and decide to take advantage of this as follows: Instead of running the air conditioner for the building during the day, you decide to run a giant refrigerator at night and make ice at night and circulate air past the ice during the day to cool air that is then sent around the building. Do see if this is worthwhile you consider the following:
   a) Your air conditioner is operating between outside temp of 90 F and inside temp of 74 F for 8 hours per day. Under these conditions, your building loses about 50 Watt per square meter and your building is roughly a 20x20x20 meter cube (ignore the side on the ground). If your air conditioning system has a coefficient of performance of 4, how much electric energy does it take to cool the building for a day?
   b) When using the ice made at night to cool the building, what is the minimum amount of ice will you need in order to supply 1 day's-worth of cooling? (Assume the ice is produced and used at 0 C). (HINT: how much ice are you left with at the end of the day if you make just the minimum needed? How much energy does that require?)
   c) If you make that much ice at night with a refrigerator of similar coefficient of performance how much electric energy will you need?
   d) If the electric rates at night are 5 times lower than during the day, is this approach economically viable? (Obviously, this neglects some factors: you still need fans to move the air during the day and the efficiency of transfer of energy from the ice to the areas to be cooled is not factored in, but this gives you a basic idea of the calculations involved).
3. Deep space probes often use a mass of radioactive material to provide power. They can do this in various ways, but usually they make use of the elevated temperature of the radioactive material due to the energy released in the radioactive decay (^{238}Pu is most common). If the ^{238}Pu is at 700C and the "cold" reservoir is deep space (where the waste heat is radiated to) at 3K then:
   a) What is the maximum possible efficiency for a heat engine operating between these two reservoirs?
   b) If the rate of energy release from the radioactive source is 500 Watts, what is the maximum useful power that could be delivered to the space probe instruments?
   c) Compare the answer to b) to the power consumed by a typical modern desktop computer (cite any sources). This should give you an appreciation for how important energy budgeting on space missions is. (Note: the New Horizons probe instruments consume at most 228 W of electric power!)