Thermal Physics, Autumn 2016 CMI
Problem set 4
Due by the beginning of lecture on Monday, Sep 12, 2016
Carnot Cycle, Second Law of Thermodynamics

1. ⟨**9**⟩ Since the Carnot cycle $ABCDA$ (introduced in the lecture) is reversible, we may run a Carnot engine E in reverse between low and high temperature reservoirs at temperatures t_1 and t_2. It is denoted $\bar{E}$.

   (a) ⟨**5**⟩ Suppose Q_1, Q_2 and W are the heats absorbed and expelled at the high and low temperature reservoirs of E and the work done. State how much heat $\bar{E}$ absorbs/expels at the various reservoirs and what work it does/is done on it (as an integral). Give a relation among these quantities. Illustrate $\bar{E}$ by an *oriented* closed curve in a pV diagram indicating the axes, temperatures and heat absorbed/expelled.

   (b) ⟨**4**⟩ Identify a household appliance that $\bar{E}$ models and say what the two reservoirs are in practice. What is the effect of the work done or source of the work absorbed? At which reservoir is heat of a larger magnitude exchanged?

2. ⟨**4**⟩ Suppose the working substance of a Carnot engine operating between gas temperatures $T_2 > T_1$ is an ideal gas. Show that the ratios of volumes V_B/V_A and V_C/V_D are equal. Here AB is the isothermal expansion at high temperature T_2 and CD the isothermal compression at T_1. BC and DA are the adiabatic expansion and compression respectively.

3. ⟨**6**⟩ We showed that the Clausius postulate implies Kelvin's postulate. Show the converse. Assume that the Clausius postulate is false and say what this would permit. Then obtain a violation of the Kelvin statement. Hint: Use a Carnot engine. Proceed without looking up the answer!