Advanced Statistical Physics, SS 2017
Sheet 3

Problem 1:   **(4 points)**

Show that the two formulations of the Second Law are equivalent. For review, the two formulations are:

Clausius: Heat cannot go from a colder body to a warmer body unless there is simultaneously another change related to it.

Planck - Thomson: It is impossible to construct a periodically working machine that does nothing else but lift a weight (do work) and cool a heat reservoir. (Such a machine is called perpetuum mobile of second kind.)

Problem 2:   **(4 points)**

    a) Show that there is no machine between two fixed temperature heat reservoirs that is more efficient than the Carnot cycle.

    b) Show that all reversible machines between two reservoirs have the same efficiency.

Problem 3:   **(4 points)**

    a) Consider a thermodynamic system with internal energy $U = U(S, V, N)$. Show that $T = \frac{\partial U}{\partial S}$ is intensive given that U, S, V and N are extensive.

    b) Suppose two systems, one with internal energy $U_1(S_1, V_1, N_1)$ and another with internal energy $U_2(S_2, V_2, N_2)$ are allowed to exchange heat (but not work or mass) through a fixed wall. Show that the second law implies that this exchange of heat cannot decrease the total entropy $S_1 + S_2$.

Hint: In Problem 1 assume that there is a process or a machine contradicting one of the two statements. Couple it with a Carnot cycle to construct a composite process or machine which contradicts the other of the two statements. Note, that a Carnot cycle may be driven in both directions, converting heat into work or work into heat. Proceed similary for Problem 2.

Deliver your hand-written solutions at the beginning of the lecture on Friday, May 5th.