8. Hausübung, **Statistische Physik**

abzugeben am Donnerstag, 8.12.2011

Aufgabe H14 *Heat pump* (4 Punkte)

A heat pump can be used to warm up a building using less work than a simple heater, by extracting heat from an external source. Let τ_i be the temperature inside the building, and τ_o be the temperature of the source the pump has access to.

a. Assuming the source is colder than the interior of the building, what is the minimal amount of work required of the pump per unit of heat delivered inside the building, as a function only of τ_i and τ_o?

b. Assume that the electricity powering an optimal heat pump is itself produced by a Carnot engine operating between the temperatures $\tau_h > \tau_o$. What is the ratio Q_h/Q_i of the heat consumed at the temperature τ_h and the heat delivered at τ_i, i.e. inside the building? Compute it in the case $\tau_h/k_B = 600$ K, $\tau_i/k_B = 300$ K, $\tau_o/k_B = 270$ K.

Aufgabe H15 *Air conditioner* (4 Punkte)

A room air conditioner functions as a Carnot cycle refrigerator between an outside temperature τ_o and a room at lower temperature τ_i. Because the room is not entirely insulated, it constantly gains heat from the outside at a rate $A(\tau_o - \tau_i)$. Express the steady state temperature inside the room as a function of the outside temperature τ_o and of the power P of the cooling unit.

Aufgabe H16 *Entropy loss of earth* (4 Punkte)

a. Last week, in problem P19, we computed the flux of energy that the earth receives from the sun and re-emits into space as thermal radiation. Express the minimum rate at which the earth can gain entropy from this process, as a function of the earth's surface temperature τ_e, the sun's surface temperature τ_s and the power P received from the sun. Observe that it is negative and therefore allows the earth to reduce its entropy. This fact makes self-organization and life on earth possible.

b. In information theory, we learn that entropy is a measure of our lack of information about a system. It is usually defined in terms of the base 2 logarithm of the number of accessible states, rather than in terms of the natural logarithm.

   Compute the rate of information that we may gain about the earth in the above process, expressed in terabits per second (1 terabit is 10^{12} bits).

   You may assume that the power received by the earth from the sun's electromagnetic radiation is $P \simeq 1.82 \cdot 10^{17}$ watts.