Ph.D. Qualifying examination

Thermodynamics

Fall 2018

Notes:

1. Duration: 2.5 hours
2. Open book (textbook provided during the exam).
3. Two problems (of equal value)
4. Calculator is allowed.
5. Laptops, cell phones, and similar internet-connected devices are not allowed.

Problem 1.

A cylindrical rod of length L insulated on its lateral surface is initially in contact at one end with a wall at temperature T_H and at the other end with a wall at a lower temperature T_C. The temperature within the rod initially varies linearly with position z according to

$$T(z) = T_H - \left(\frac{T_H - T_C}{L} \right) z$$

The rod is insulated on its ends and eventually comes to a final equilibrium state where the temperature is T_f.

a) Evaluate T_f in terms of T_H and T_C. (20 points)

b) Show that the amount of entropy produced is:

$$\sigma = m c \left(1 + l n T_f + \frac{T_C}{T_H - T_C} \ln T_C - \frac{T_H}{T_H - T_C} \ln T_H \right)$$

where c is the specific heat of the rod. (30 points)

Problem 2.

Consider an ideal vapor-compression refrigeration cycle operating between pressures of 0.14 and 0.80 Mpa. The flow rate of the refrigerant (R134a) is 0.04 kg/s. First, sketch the cycle on a *T-s* diagram (20 points). Then, determine the rate at which energy is removed from the cold space, the rate at which energy is rejected to the surroundings, the power input to the compressor, and the coefficient of performance (30 points).