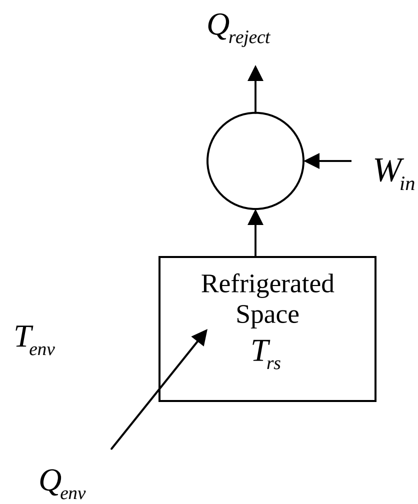
Problem 1



Consider the refrigeration system shown above. We would like to find the work per cycle, W_{in}, necessary to keep the temperature of the refrigerated space at $T_{rs} = 1^oC$. The temperature of the environment is $T_{env} = 21^oC$, and heat (per cycle) from the environment is conducted into the refrigerated space according to the relation

$$Q_{env} = c_1 \left(T_{env} - T_{rs} \right)$$

where $c_1 = 75\ kJ/°C$-cycle.
The coefficient of the performance of the refrigeration system is 2.8.

i Find the required work per cycle, W_{in}.

ii Find the heat rejected to the environment per cycle, Q_{reject}.

If the refrigeration system is suddenly turned off, the temperature of the refrigerated space would rise. We would like to find T_{rs} as a function of time.

Assume the energy of the refrigerated space is given by

$$E_{rs} = c_2\ T_{rs}$$

iii Write down a differential equation governing T_{rs}, in terms of c_1, c_2, T_{env} and N (no. of cycles/sec.) and time *t*.

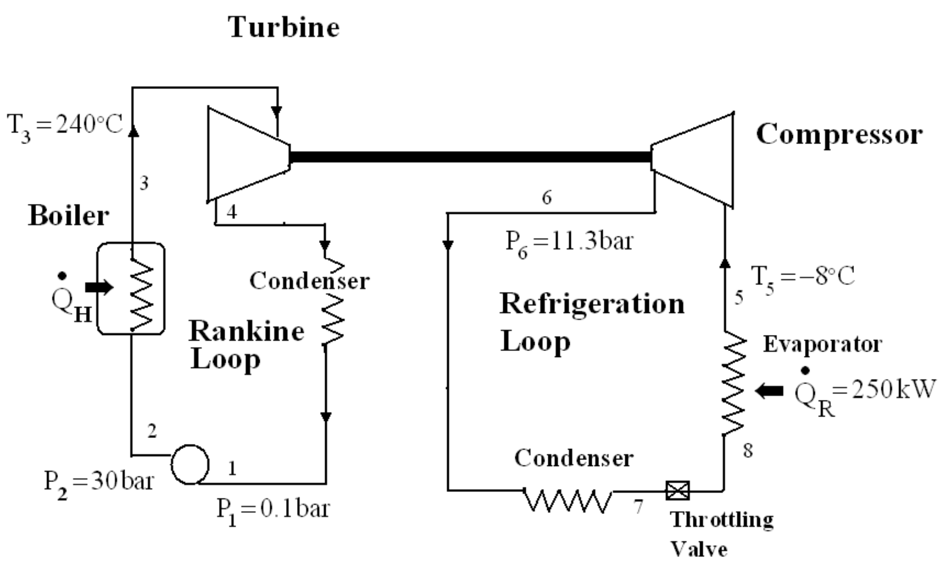
iv Solve the equation of part iii for T_{rs}. Let $T_{rs} = \left(T_{rs}\right)_o$ @ $t = 0$.

Problem 2

An ideal Rankine cycle that uses water as the working fluid is used to power the compressor of an ideal vapor refrigeration cycle. The two cycles are matched so that the power generated by the turbine exactly matches the power needed by the compressor. The refrigeration cycle works with R-134a. The R-134a that enters the compressor is saturated vapor at –8 ºC. Water that enters the Rankine cycle pump, and R-134a entering the throttle valve, are both saturated liquid. The refrigerant evaporator provides 15 kW of cooling. Find:

a) The mass flow rates of water and R-134a

b) The rate of heat input to the Rankine cycle boiler, $\dot{Q}_H$.



Problem 3

A frictionless, adiabatic, piston/cylinder is loaded with a linear spring, as shown below. The spring constant 200 kN/m and the piston cross-sectional area is 0.1 m^2. Initially, the cylinder contains 20 L (0.020 m^3) of air at 200 kPa and at a temperature 10°C. The cylinder has a set of stops that prevent its volume from exceeding 50 L. A valve connects to a line flowing air at 800 kPa and 50°C.

The valve is now opened to allow warm air to quickly flow into the cylinder until its inner pressure is the same as that of the supply line. The valve is then closed and the process ends.

a) Determine the final mass and temperature of the air inside the cylinder.

b) Calculate the total entropy generation for this process.

For air, assume constant $c_p = 1.004 \text{ kJ/kg} \cdot \text{K}$ and $c_v = 0.717 \text{ kJ/kg} \cdot \text{K}$

You may also assume: $u = c_v T$ $h = c_p T$