CANKAYA UNIVERSITY

FACULTY OF ENGINEERING AND ARCHITECTURE

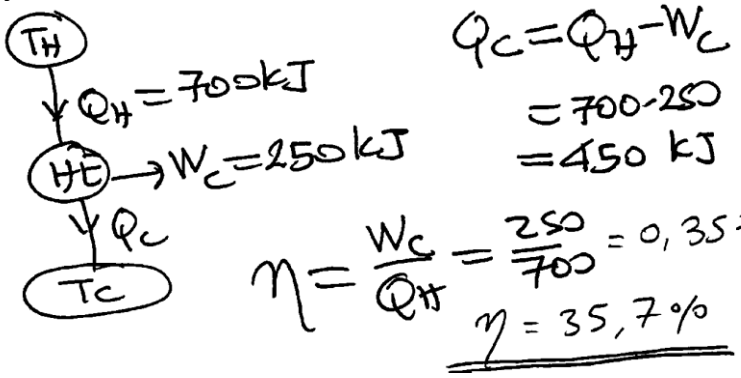
MECHANICAL ENGINEERING DEPARTMENT

ME 211 THERMODYNAMICS I

FALL 2016

HW # 5-Solution

1) A heat engine that pumps water out of an underground mine accepts 700 kJ of heat and produces 250 kJ of work. How much heat does it reject, in kJ? Determine the engine efficiency?



$Q_C = Q_H - W_C$

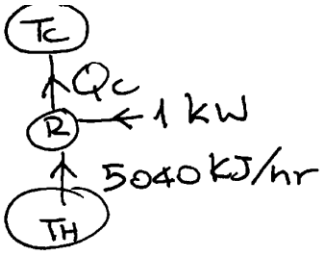
$= 700 - 250$

$= 450\ kJ$

$\eta = \frac{W_C}{Q_H} = \frac{250}{700} = 0,357$

$\eta = 35,7\%$

2) Determine the COP of a refrigerator that removes heat from the food compartment at a rate of 5040 kJ/h for each kW of power it consumes. Also, determine the rate of heat rejection to the outside air.

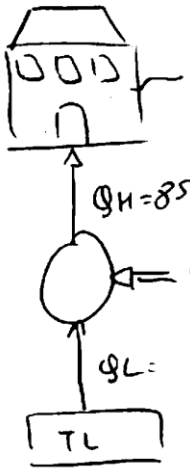


$\gamma = \frac{\dot{Q}_C}{\dot{W}_C} = \frac{5040\ \frac{kJ}{hr}}{1\ kW} \quad \frac{kW}{3600\ \frac{kJ}{hr}} = 1.4$

$\dot{Q}_C + \dot{W}_C = \dot{Q}_H$

$\dot{Q}_H = 5040 + (1)(3600\ \frac{kJ}{hr}) = 8640\ kJ/hr$

3) Determine the COP of a heat pump that supplies energy to a house at a rate of 8500 kJ/h for each kW of electric power it draws. Also, determine the rate of energy absorption from the outdoor air.



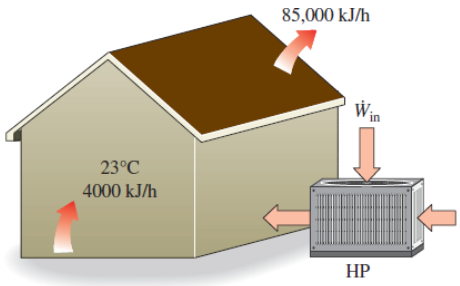
$$COP = \frac{Q_H}{W} = \frac{8500/3600}{1}$$

$$COP = \gamma = 2.361$$

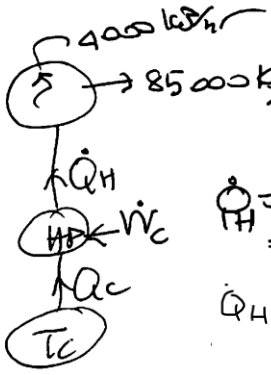
$$Q_L = Q_H - W = 1.361\ kW$$

$$Q_L = 4899.6\ kJ/h$$

4) A heat pump is used to maintain a house at a constant temperature of 23 ^{0}C. The house is losing heat to the outside air through the walls and the windows at a rate of 85,000 kJ/h while the energy generated within the house from people, lights, and appliances amounts to 4000 kJ/h. For a COP of 3.2, determine the required power input to the heat pump.



How much energy is extracted from the cold air?



$$\dot{Q}_H = 85000 - 4000 = 81000\ kJ/hr$$

$$\dot{Q}_H = \frac{81000}{3600} = 22.5\ kW$$

$$\dot{W}_c = \frac{\dot{Q}_H}{\beta} = \frac{81000\ kJ/hr}{3.2} \frac{kW}{3600\ kJ/hr} = 7.03\ kW$$

$$\dot{W}_c + \dot{Q}_c = \dot{Q}_H \qquad \dot{Q}_c = \dot{Q}_H - \dot{W}_c = 15.47\ kW$$

5) A Carnot heat engine receives 650 kJ of heat from a source of unknown temperature and rejects 250 kJ of it to a sink at 248C. Determine (*a*) the temperature of the source and (*b*) the thermal efficiency of the heat engine.

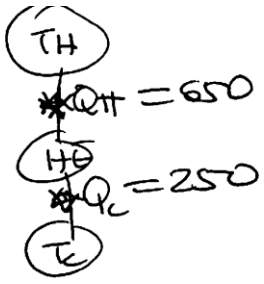
5)

$\frac{Q_H}{Q_C} = \frac{T_H}{T_C}$

$T_H = \left(\frac{Q_H}{Q_C}\right) T_C$

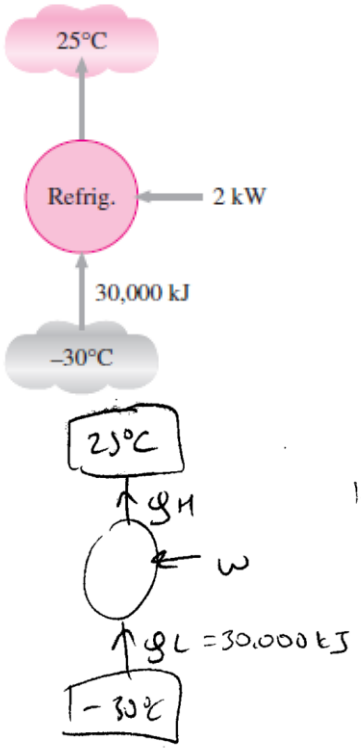
$= \frac{650}{250}(297)$

$= 772.2K$



$\eta = 1 - \frac{T_C}{T_H} = 1 - \frac{297}{772} = 0.615$

6) An inventor claims that a refrigerator that draws 2 kW of power has removed 30,000 kJ of heat from the refrigerated space during 25 minutes, which is maintained at -30°C. Is this claim reasonable if the refrigerator is in a room at 25°C? Why?



$\beta = \frac{Q_L}{W} = \frac{Q_L}{Q_H - Q_L}$

$\beta_{max} = \frac{T_L}{T_H - T_L} = \frac{(273-30)}{(25+30)} = 4.42$

$W_{net,in} = \dot{W} \cdot \Delta t = 2 \cdot 25 \cdot 60 = 3000\ kJ$

$\beta = \frac{30000}{3000} = 10$

$10 > 4.42 \Rightarrow$ impossible