Homework #5

MEMS 0051 - Introduction to Thermodynamics

Assigned February 16$^{\text{th}}$, 2019
Due: February 22$^{\text{nd}}$, 2019

Problem #1

A gasoline engine produces 15 hp using 40 kW of heat transfer from burning fuel. What is its thermal efficiency, and how much power is rejected to the ambient surroundings

Problem #2

A window air-conditioner unit is placed on a laboratory bench and tested in cooling mode using 750 [W] of electric power with a COP of 1.75. What is the cooling power capacity, and what is the net effect on the laboratory?

Problem #3

For each of the following devices, draw a schematic that labels and quantifies all of the energy flows $(\dot{W}, \dot{Q}_H, \dot{Q}_L)$ between two thermal reservoirs (T_H, T_L). Then calculate the correct metric of performance $(\eta, \beta, \text{ or } \beta')$ for each device.
  a) A heat engine that converts 800 [kW] of heat into 250 [kW] of power.
  b) A refrigerator with a power input of 300 [kW] that rejects 1000 [kW] of heat to the environment.
  c) A heat pump that takes in 500 [kW] of heat and outputs 700 [kW] of heat.

Problem #4

Consider a heat engine and heat pump connected as shown in Fig. 1. Assume $T_{H1} = T_{H2} > T_{\text{amb}}$. For each case, determine if the setup satisfies the first law and/or violates the second law. (*Note:* Be sure to indicate which postulate(s), if applicable, are violated by the second law)
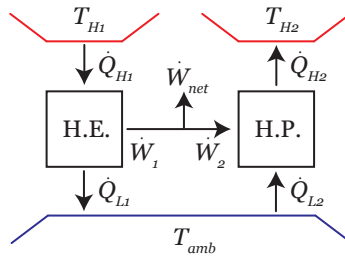

Figure 1: Schematic for Problem #4.

	$\dot{Q}_{H1}$	$\dot{Q}_{L1}$	$\dot{W}_1$	$\dot{Q}_{H2}$	$\dot{Q}_{L2}$	$\dot{W}_2$
Case 1	6	4	2	3	2	1
Case 2	6	4	2	5	4	1
Case 3	3	2	1	4	3	1

Problem #5

Consider the refrigeration cycle shown below, where a refrigerant cycles through a compressor, an evaporator, an expansion valve, and a condenser. The compressor requires an electrical input, the evaporator removes heat from the inside of the refrigerator, and the condenser rejects heat to the air in the room.
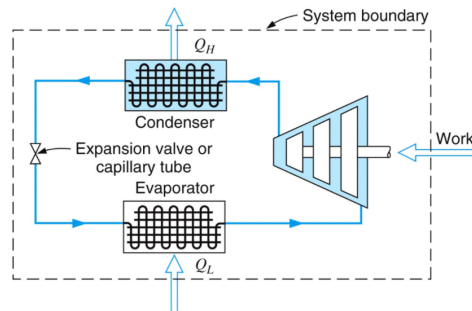
a) What are some sources of irreversibility in this cycle? List at least two.
b) What are some modifications you could make to this system to make it more reversible? Describe at least two modifications.