

QUESTION 1 [15 Marks]

- a) It is commonly known that gasoline and diesel engines are widely used in automobile. Discuss how gasoline engine and diesel engine differ in regards to the engineering thermodynamics perspective. **(5 Marks)**
- b) A four-cylinder two-stroke 2.4-L diesel engine that operates on an ideal Diesel cycle has a compression ratio of 17 and a cutoff ratio of 2.2. Air is at 55°C and 97 kPa at the beginning of the compression process. Using the cold-air standard assumptions, determine how much power the engine will deliver at 1500 rpm. **(10 Marks)**

QUESTION 2 [28 Marks]

A power producer company plans to install a steam power plant that operates on a reheat Rankine cycle as shown in **Figure Q2**. The plant is able to produce net power output of 5000 kW. Two units of turbines have been considered in the design namely high-pressure and low-pressure turbines. The turbines are designed to handle steam with quality of at least of 0.85. In the preliminary design, superheated steam enters the high-pressure turbine at 8 MPa, 350°C and the low-pressure turbine at 1.2 MPa, 350°C of pressure and temperature, respectively. The steam leaves the condenser as a saturated liquid at a pressure of 50 kPa. The isentropic efficiency of the turbines and pump are neglected in analyzing the system performance. Determine:

- the T - s sketch diagram of the cycle, **(2 marks)**
- the quality of the steam at the turbines exit, **(14 marks)**
- the thermal efficiency of the cycle, **(3 marks)**
- the mass flow rate of the steam, and **(2 marks)**
- the company has another option to change the plant performance. While maintaining the same steam inlet temperature of the turbine, the reheating pressure is increased to 3 MPa, and the condensate pressure is changed to 10 kPa. Based on your engineering knowledge in this area, would you recommend this option to the company (Please provide your evidence of calculation and sketch of T - s diagram to support your answer). **(7 marks)**

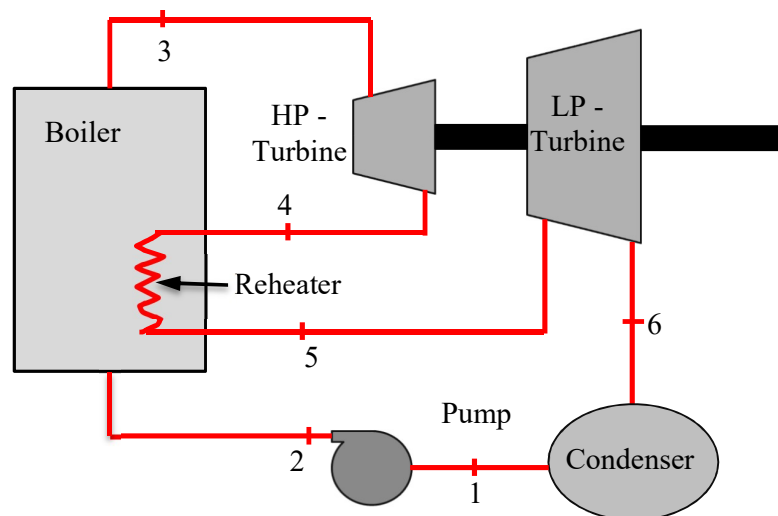


Figure Q2

QUESTION 3 [25 Marks]

a) A refrigerator uses refrigerant-134a as the working fluid and operates on the ideal vapor-compression refrigeration cycle as shown in **Figure Q3a**. The refrigerant enters the evaporator at 120 kPa with a quality of 30 percent and leaves the compressor at 60°C. If the compressor consumes 450 W of power, determine:

- i. the condenser pressure, **(7 Marks)**
- ii. the mass flow rate of the refrigerant, and **(5 Marks)**
- iii. the COP of the refrigerator. **(3 Marks)**

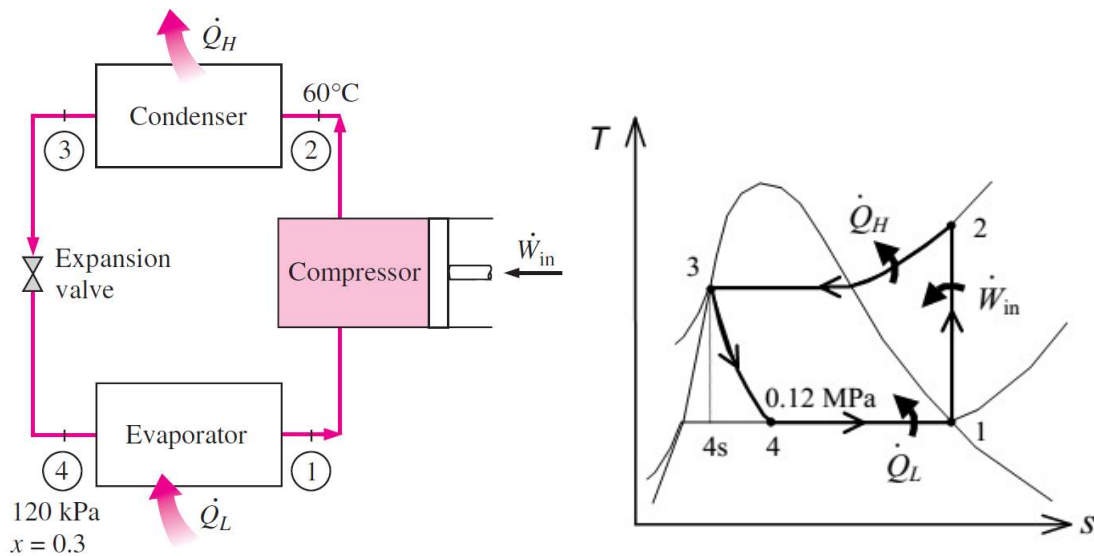


Figure Q3a

b) A heat pump using refrigerant-134a operated on the actual vapor-compression cycle heats a house by using underground water as the heat source. The refrigerant enters the compressor at 280 kPa and 0°C, and leaves it at 1 MPa and 60°C. The refrigerant exits the condenser at 30°C. If the house is losing heat at a rate of 60000 kJ/h, determine:

- i. the power input to the heat pump, and **(7 Marks)**
- ii. the increase in electric power input if an electric resistance heater is used instead of a heat pump. **(3 Marks)**

QUESTION 4 [15 Marks]

An air-conditioning system is to take in air at 1 atm, 34°C, and 70 percent relative humidity and delivers it at 22°C and 50 percent relative humidity as shown in **Figure Q4**. The air flows first over the cooling coils, where it is cooled and dehumidified, and then over the resistance heating wires, where it is heated to the desired temperature. There is no change of humidity ratio (ω) from point 2 to point 3. Assuming that the condensate water is removed from the cooling section at 10°C, determine;

- the temperature of air before it enters the heating section, **(7 Marks)**
- the amount of heat removed in the cooling section, and **(5 Marks)**
- the amount of heat transferred in the heating section, both in kJ/kg dry air. **(3 Marks)**

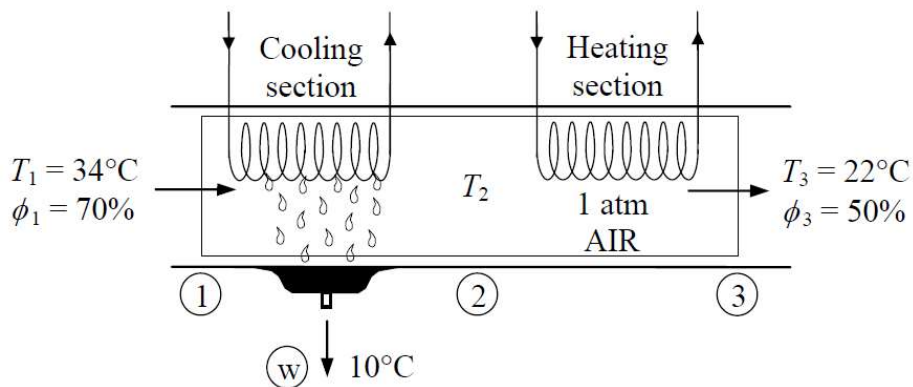


Figure Q4

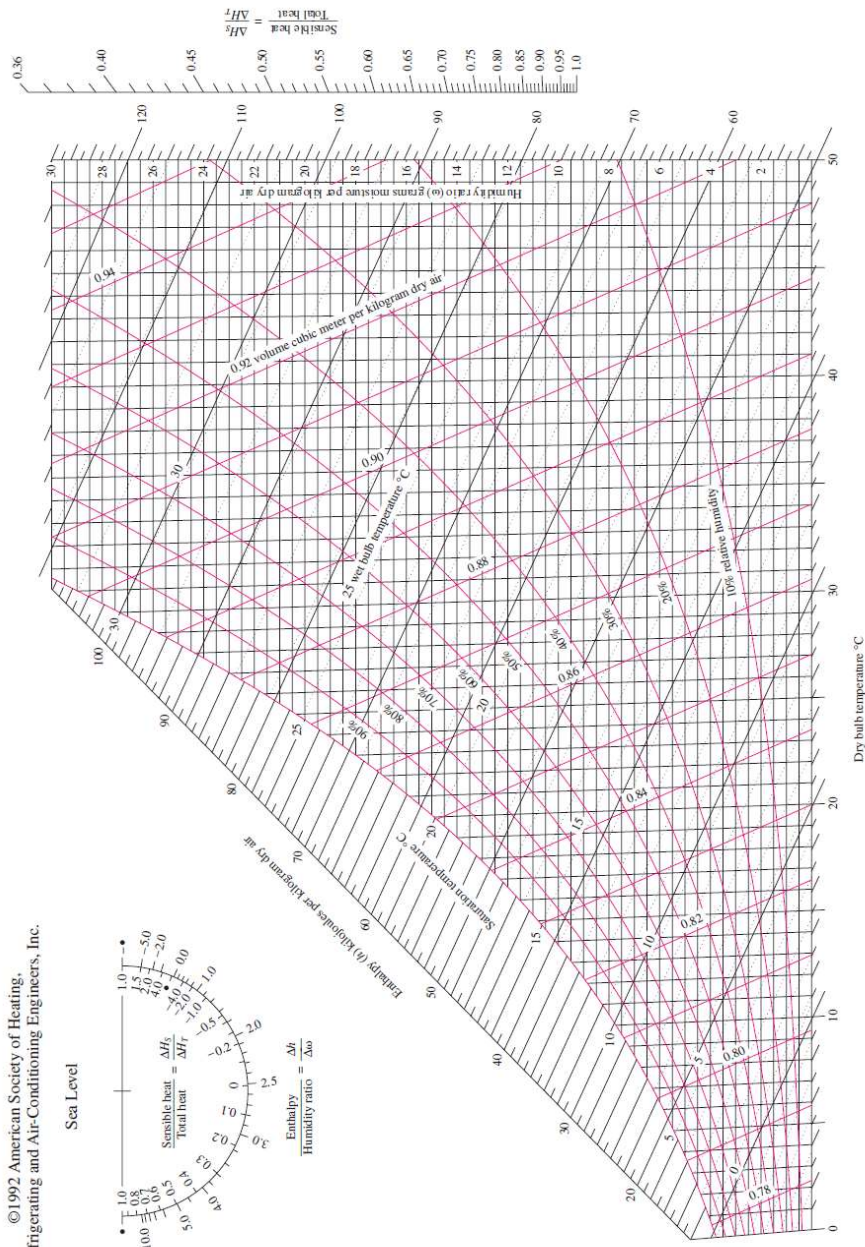
QUESTION 5 [17 Marks]

Consider butane fuel (C_4H_{10}) which is combusted with theoretical amount of air. The products of the combustion are CO_2 , H_2O and N_2 . Execute combustion analysis to determine the following parameter;

- a) the chemical equation of the combustion, **(6 Marks)**
- b) the mass fraction of CO_2 , **(2 Marks)**
- c) the mole fraction of water vapor, **(2 Marks)**
- d) the mass fraction of water vapor, and **(2 Marks)**
- e) the air-fuel ratio for the combustion process. **(5 Marks)**

APPENDIX

Psychrometric Chart at 1 atm Total Pressure



ASHRAE Psychrometric Chart No. 1
 Normal Temperature
 Barometric Pressure: 101.325 kPa

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Sea Level

