Continuous Assessment Test – I

VIT
Vellore Institute of Technology

Programme Name & Branch: B.Tech (BEM, BME, BMA)

Course Name & Code: Thermal and Heat Transfer (MEE2038)

Class Number: VL2019201001128 **Slot:** C1/TC1/V2 **Exam Duration:** 90 mins

Maximum Marks: 50

General instruction(s):

Steam table is permitted

Answer all the questions

1. A single-cylinder double acting reciprocating air compressor delivers 20 m^3/min of air when it is running at 400 rpm. The pressure and temperature at the beginning of compression are 0.95 bar and 30 ^{0}C whereas the pressure and temperature at the intake conditions are 1.03 bar and 28 ^{0}C respectively. Assume the compression and expansion follow the law $PV^{1.35} = C$. If the clearance volume is 5 % of the stroke volume and for the required delivery pressure of 10 bar. Calculate the following
   a) Stroke volume **(3 Marks)**
   b) Power required to run the compressor **(4 Marks)**
   c) Isothermal efficiency **(3 Marks)**

2. A two-stage double acting reciprocating air compressor delivers 10 m^3/min of air when it is running at 150 rpm. The pressure and temperature at the beginning of compression are 1 bar and 28 ^{0}C. The required delivery pressure from the compressor is 30 bar. Consider the clearance volume of both low and high pressure cylinders as 4 % of their respective stroke volumes. Assuming perfect inter-cooling between the two stages and both compression and expansion follow $PV^{1.35} = C$, find the following
   a) Minimum power required to run the compressor **(4 Marks)**
   b) Diameter and stroke lengths for both cylinders (assume stroke length = 1.5 times the diameter for both cylinders) **(4 Marks)**
   c) Heat rejected in the inter-cooler **(2 Marks)**

3.
   a) The capacity of a refrigerator that is working based on Carnot cycle is 10 tons. If the operating temperature for this refrigeration unit is -5 ^{0}C to 30 ^{0}C, find the power required to run this refrigeration unit **(4 Marks)**
   b) A refrigerator working on Bell-Coleman cycle has a capacity of 6 tons. The temperature of air coming out from the cold space is at 5 ^{0}C. It is then compressed adiabatically to 6 bar and finally cooled to 35 ^{0}C before expansion. Assume the expansion is also adiabatic. Calculate the COP and heat rejected in the heat exchanger **(6 Marks)**

4. A refrigerator unit working on vapour compression cycle uses ammonia as refrigerant. The operating temperature of the refrigerator is between -15 ^{0}C and 35 ^{0}C. The condition of refrigerant is 0.95 dry when it enters the compressor, whereas it leaves as a saturated liquid from the condenser. The thermodynamic properties of ammonia at the operating temperature limits are given below in Table 1. For this refrigerator unit, calculate the following
   a) Refrigeration effect **(4 Marks)**
   b) Work input to the compressor **(4 Marks)**
   c) Condition (dryness fraction) of refrigerant at the entry of evaporator **(2 Marks)**

5.

a) List down the required properties of ideal refrigerant **(3 Marks)**

b) The temperature and pressure of air in a room of size 10 m × 10m × 15 m is 25 ^{0}C dry bulb temperature and 1 bar. The relative humidity of air in the room is 60 %. For this condition, determine

i. Partial pressure of dry air
ii. Specific humidity
iii. Enthalpy per unit mass of dry air
iv. Mass of water vapour and dry air in the room (Take Characteristic gas constant for dry air and water vapour as 287 J/kg-K and 461.4 J/kg-K respectively)

(7 Marks)

Table 1: Thermodynamic property values of Ammonia refrigerant at liquid and vapour state

Temperature (°C)	**Specific enthalpy (kJ/kg)**		**Specific entropy (kJ/kg-K)**		**Specific heat (kJ/kg-K)**	
	Liquid	Vapour	Liquid	Vapour	Liquid	Vapour
-15	112.3	1426	0.457	5.549	-	-
35	347.5	1471	1.282	4.930	4.6	2.8