B.E. INSTRUMENTATION AND ELECTRONICS ENGINEERING ,FIRST YEAR , SECOND SEMESTER - 2018

APPLIED THERMODYNAMICS

Time: 3 (Three) hours **Full Marks: 1 00**

N.B. On the top of the answer paper, write the code# provided in your question. Answer any 5 question out of 7, each of them carries equat marks.

Q 1: (a) Write 'the first law of thermodynamics' in a general equation form involving heat, work and internal energy; clearly mention the sign convention that you have used for different quantities. **4 Marks**

(b) Re-write Q 1(a), except, use the sign convention for 'heat' opposite to that you have used earlier. **4 Marks**

(c) During a process 2.20 KJ heat is added to the system, and 4.10 KJ work is done on the system. Find the increase in internal energy of the system during the process; solve the problem using both the sign conventions that you have used in Q 1(a) and Q 1(b). **6 Marks**

(d) What do you understand by 'the equation of state' of a thermodynamical system? Write the equation of state for a system containing 'ideal gas'; write SI units of all quantities. **6 Marks**

Q 2: (a) Write both the Kelvin-Planck statement and the Clausius statement of 'the second law of thermodynamics'. **4 Marks**

(b) Show that the violation of the Clausius statement implies the violation of the Kelvin-Planck statement. **7 Marks**

(c) The entropy of 3 moles of an ideal gas increases by 18.0 J/K due to isothermal expansion. How many times should the volume of the gas be increaed in the process? **9 Marks**

Q 3: A rigid closed vessel of cylindrical shape, having 0.5m length and 0.55m diameter contains 2kg of liquid water and water vapour mixture at equilibrium, at a pressure 300 kPa.

(a) Find the volume and mass of liquid. Also find the volume and mass of vapour. **10 Marks**

(b) The system is cooled down by $10°C$. Find the new pressure. Also find the total amount of heat rejected by the system; neglect the change of volume of the

vessel. **10 Marks**

Q 4: Consider a thin (i.e. 2-D) rectangular metallic plate of length 'L' (horizontal) and height 'H' (vertical). The origin lies at the centroid of the rectangle; the x and z axes are in the horizontal and vertical direction respectively. The right, top and left walls are at temparature T_2 and the fourth wall is at the temperature T_1 respectively, with $T_2 > T_1$.
(a) Write the unsteady 3-D heat conduction equation (for constant thermal conductivity) with volumetric generation term using (i) vector notation (i.e. use the operator ∇) (ii) for rectangular cartesian system. Explain the meanings of all the symbols
(b) We will consider steady state heat conduction, without any generation term in the above mentioned rectangular plate. Reduce the 3-D equation to a 2-D equation suitable for analysis for the give axes; mention the reason for dropping each term.
(c) Non-dimensionalyze the temperature using suitable transformation so that the boundary temperature lies between 0 and 1. Write the 2-D equation using the transformed temperature. Write the boundary conditions.
(d) Obtain general solution to the equation using separation of variables. (particular solution not required). **Total 20 Marks**

Q 5: In a Rankine cycle, steam is produced at 2.0 MPa pressure, superheated to 350 $°C$; the steam comes out of the turbine with velocity 600 m/s at a pressure 140 kPa; it is then cooled to saturated liquid at that pressure.
(a) Find the work output from the turbine; neglect velocty at turbine entry.
(b) If the steam were expanded right from the saturated vapour state, what would have been the percentage reduction in work output from the turbine?
(c) How much heat will be rejected in the condenser for Q 5(a) and Q 5(b)? ——— **Total 20 Marks**

Q 6: **(a)** What is 'air standard cycle'?
(b) Determine the thermal efficiency of the Brayton cycle.
(c) What type of IC engine requirs a 'carburator'? what is the use of 'carburator'? In a diagram, show different parts of a carburator. Explain how it works. ——— **Total 20 Marks**

Q 7: **(a)** Using T-S diagram, briefly describe how a vapour compression refrigeration cycle works. **7 Marks**
(b) What is steam turbine governing? Explain with diagram how a govenor, equipped with flyballs, works. **7 Marks**
(c) What is 'convective heat transfer'? How do we define convective heat transfer coefficient 'h'? **6 Marks**