AU – 2500

Third Semester B. E. (Mechanical Engineering) (CGS) Examination

ENGINEERING THERMODYNAMICS

Paper – 3 ME 04

(USC – 10830)

P. Pages : 4

Time : Three Hours] [Max. Marks : 80

Note : (1) Answer **Three** questions from Section A and **Three** questions from Section B as directed.
(2) Due credit will be given to neatness and adequate dimensions.
(3) Assume suitable data wherever necessary.
(4) Illustrate your answer wherever necessary with the help of neat sketches.

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SECTION A

1. (a) Define the terms state, Property, Process and cycle of a thermodynamic system. 4

(b) Define quasi–static process. State its salient features. 3

(c) Two spheres, each of capacity $2m^3$, are connected by a pipe with a valve inserted in between. When the valve lies in the closed position one sphere contains oxygen at 50 kPa and 320 K and the other contains oxygen at 45 kPa and 290 K. Subsequently the valve is opened and the entire system is allowed to attain the equilibrium conditions. At this state, the final temperature is noted to be 300 K. Presuming that the volume of the connecting pipe is negligible, determine the final pressure of the composite system. 6

OR

2. (a) Prove the characteristics gas equation pv = mRT. 4

(b) What do you understand by thermodynamic equilibrium. 4

(c) An automobile vehicle of 1500 kg mass is running at a speed of 60 km/hr. The brakes are applied and the vehicle is brought to rest. Calculate the rise in temperature of the brakes if their mass is 15 kg. Take specific heat of the brake material = 0.46 kJ/kgK. 5

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3. (a) Define the following :

   (i) Enthalpy (ii) Internal Energy

   (iii) Flow work 3

   (b) State first law of thermodynamics. Apply it to reversible adiabatic process and show that : Pv^r = constant for adiabatic process. 5

   (c) 5–kg of air at 150 kPa and 300^0C is compressed polytropically until the pressure and temperature becomes 1500 kPa and 500^0C respectively Evaluate polytropic workdone and heat transferred during the process. 5

OR

4. (a) Show that for a polytropic process the heat transfer is given by :

$$Q_{1-2} = \frac{r-n}{r-1} \times \text{polytropic workdone}$$

6

   (b) A ideal gas with a mass of 0.9 kg has characteristic gas constant of 287 J/kgK. It is heated at constant pressure of 8 bar from 30^0C to 200^0C. If specific heat at constant pressure is 1.005 kJ/kgK,
   Determine :

   (i) Specific heat constant volume.

   (ii) Heat supplied to gas.

   (iii) Increase in internal energy.

   (iv) Workdone during the process. 1+2+2+2=7

5. (a) State the limitations of first law of thermodynamics. 3

   (b) Defind steady flow process. What are the conditions for a steady flow process ? 3

   (c) 2 kg/s of air at 15^0C is raised to 800^0C by passing it through heat exchanger. At the exit of heat exchanger air possesses a velocity of 30 m/s. Then the air enters a nozzle where it expands until the temperature has fallen to 700^0C. On leaving the nozzle air enters a turbine and gets expanded until the temperature has fallen to 450^0C and velocity of 60 m/s
   Determine :

   (i) Rate of heat transfer to air in H.E.

   (ii) Power output from turbine assuming no heat loss and.

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(iii) Velocity at exit from nozzle assuming no heat loss.

Take the enthalpy of air h = cpt, where Cp is the specific heat equal to 1.005 kJ/kgK and t is the temperature in ^{0}C. 8

OR

6. (a) Derive general energy equation for variable flow process. 5

(b) A perfect gas flow through a nozzle where it expands in a reversible adiabatic manner. The inlet conditions are 22 bar, 500^{0}C, 38 m/s. At exit the pressure is 2 bar. Determine the exit velocity and exit area if the flow rate is 4 kg/s. Take R = 190 J/kgK and r = 1.35. 5

(c) State significance of $\int_1^2 p.d.v$ and $\int_1^2 r.dp$ work 4

SECTION B

7. (a) What is thermal energy reservoir ? Explain the terms "source" and "sink". 3

(b) What is heat pump ? How does it differ from refrigerator ? Show that cop of a heat pump is greater than COP of refrigerator by unity. 4

(c) A cold storage is maintained at 268^{0}K, while the surroundings is at 308^{0}K. The heat leakage from the surroundings into the cold storage is estimated as 29 kJ/s. Determine the power required to run the cold storage plant if the actual COP is 30% of the ideal COP between the same temperature limits. 6

OR

8. (a) State the two statement of second law of thermodynamics and prove their equivalence. 7

(b) A reversed carnot cycle operating as a refrigerator has a refrigeration capacity of 100 kJ/s while operating between temperature limits of 20^{0}C and 35^{0}C.

Determine :

(i) Power output and (ii) COP

If the system is used for heating purpose only find its COP. What would be its efficiency if it runs as an engine ? 6

9. (a) Explain "entropy" and prove claysius inequality with proper diagram. 5

(b) 2 m^3 at hydrogen at a pressure of 1 bar and 20^0C is compressed isentropically to 4 bar. The same gas is expanded isothermally to original volume finally the gas pressure is restored to the original value by constant volume heat rejection process. Determine the change in internal energy and entropy during each process. R = 4.206 kJ/kgk and Cp = 14.25 kJ/kgK for hydrogen. 8

OR

10. (a) What are Helmholtz function and Gibb's function ? 4

(b) Show that the transfer of heat through finite temperature difference is irreversible. 4

(c) A single stage air turbine is to operate with an inlet pressure and temperature of 6 bar and 800 K. The outlet pressure and temperature are 1.0 bar and 500 K. During expansion the turbine loses 25 kJ/kg to the surroundings which are at 1 bar and 300K. For unit mass flow rate, determine the decrease in availability, the maximum work and the irreversibility.

For air take Cp = 1.005 kJ/kgK and R = 0.287 kJ/kgK. 5

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11. (a) Derive an expression for air standard efficiency of a dual combustion cycle. 8

(b) An engine working on otto cycle is supplied with air at 0.1 MPa, 35^0C. The compression ratio is 8. Heat supplied is 2100 kJ/kg. Calculate the maximum pressure and temperature of the cycle, the cycle efficiency and the mean effective pressure. 6

OR

12. (a) Derive expression for thermal efficiency of Brayton cycle ? 5

(b) Compare n^{th} of otto diesel and dual cycle for same max^m pressure and temperature and same heat rejection. 4

(c) Plot efficiency of air standard otto cycle as function of compression ratio for compression ratios from 4 to 16. 5

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