ENGINEERING THERMODYNAMICS & FLUID MECHANICS (MECH 1201)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) A PMM1
(a) continuously delivers work in absence of any input energy
(b) causes heat transfer from a low temperature body to a high temperature body
(c) causes heat transfer from a high temperature body to a low temperature body
(d) delivers heat in absence of any input energy.

(ii) Work output from a system is at the expense of internal energy in a non–flow process carried out
(a) at constant pressure (b) at constant volume
(c) adiabatically (d) polytropically.

(iii) Enthalpy of a system does not change during
(a) isentropic process (b) any reversible process
(c) throttling process (d) isochoric process.

(iv) In Bernoulli's equation for an ideal fluid, each of the terms represents
(a) energy in kg.m/kg mass of fluid (b) energy in N.m/kg mass of fluid
(c) energy in N.m/N weight of fluid (d) power in kW/kg mass of fluid.

(v) In air standard Otto cycle, net change in internal energy
(a) depends on compression ratio (b) depends on temperature
(c) always equal to zero (d) may have any value.

(vi) A constant temperature heat source is a body of
(a) infinite mass (b) infinite heat capacity
(c) infinite specific heat (d) all of these.

(vii) Zeroth law**:** temperature **::** second law**:** ________
(a) efficiency (b) enthalpy
(c) internal energy (d) entropy.

(viii) No heat engine can operate by exchanging heat with a single temperature source. This statement refers to
(a) Joule's law (b) Carnot's theorem
(c) Clausius statement (d) Kelvin-Planck statement.

(ix) Newton's law of viscosity relates to
(a) angular deformation, velocity and viscosity
(b) shear stress and rate of angular deformation
(c) shear stress, temperature, viscosity and velocity
(d) pressure, viscosity and rate of angular deformation.

(x) The continuity equation $\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}+\frac{\partial w}{\partial z}=0$
(a) is not valid for unsteady, incompressible fluids
(b) is valid for incompressible fluids whether the flow is steady or unsteady
(c) is valid for steady flows whether compressible or incompressible
(d) is valid for ideal fluid flow only.

Group – B

2. (a) (i) State zeroth law of thermodynamics.

(ii) A piston-cylinder device contains 0.05 m^3 of a gas initially at 200 kPa. At this state, a linear spring having a spring constant of 150 kN/m is touching the piston but exerting no force on it. Now heat is transferred to the gas, causing the piston to rise and to compress the spring until the volume inside the cylinder doubles. If the cross-sectional area of the piston is 0.25 m^2, determine (a) the final pressure inside the cylinder, (b) the total work done by the gas. Assume the process is quasi static.

(b) A gas undergoes a thermodynamic cycle consisting of three processes beginning at an initial state where p_1 = 1 bar, V_1 = 1.5 m^3 and U_1= 512 kJ. The processes are as follows:
(i) Process 1–2: Quasi static compression with pV = constant to p_2 = 2 bar, U_2= 690 kJ
(ii) Process 2–3: W_{23} = 0, Q_{23} = –150 kJ and
(iii) Process 3–1: W_{31} = **+**50 kJ.
Neglecting kinetic and potential energy changes, determine the heat interactions Q_{12} and Q_{31}.

[2 + (2 + 3)] + (3 + 2) = 12

3. (a) A cylinder contains 1.25m^3 of an ideal gas at 80 kPa, 375K. The gas is compressed following a quasistaic, polytropic process and the volume of gas is reduced to one-fourth of its initial volume. The final pressure of the gas is 480 kPa. Calculate the mass of the gas, the total work done and the total heat transfer during the compression process.

Take R = 287 J/kg-K, c_v = 0.718 kJ/kg-K, γ = 1.4 for the gas

(b) What is an isolated system? With the help of 1st law of thermodynamics, show that the energy of an isolated system is constant. A spring of spring constant = 10 N/mm is slowly stretched by 1 cm. What is the work done by the spring? What is the change in energy of the spring?

(2 + 2 + 3) + (1 + 2 + 2) = 12

Group – C

4. (a) A steam turbine in a power plant develops 6000 kW. The heat supplied to the steam in boiler is 6600 kJ/kg, the heat rejected by the steam in the condenser is 2600 kJ/kg. The feed-pump work required to pump the condensate back into the boiler is 20 kW. Calculate the mass-flow rate of the steam.

(b) Three Carnot heat engines A, B, C work in series between the temperature limits 1000K and 300K, where A is receiving heat from 1000K source and C is rejecting heat to 300K sink. The work output is in the ratio of $W_A : W_B : W_C = 5 : 4 : 3$. Determine the intermediate temperatures between (i) engines A and B and (ii) engines B and C.

6 + (3 + 3) = 12

5. (a) A reversible heat engine receives heat from two thermal reservoirs maintained at constant temperatures of 750 K and 500 K. The engine develops 100 kW and rejects 3600 kJ/min of heat to a heat sink at constant temperature of 250 K. Determine the thermal efficiency of the engine and heat supplied by each reservoir.

(b) A blower handles 2 kg/s of air at 300 K and consumes a power of 30 kW. The inlet and outlet velocities of air are 100 m/s and 150 m/s respectively. Find the exit air temperature assuming adiabatic conditions. Take c_p of air to be 1.005 kJ/kg-K.

6 + 6 = 12

Group – D

6. (a) 2 litre of crude oil weighs 19.2 N. Calculate the specific weight, density and specific gravity of the oil. Take g = 9.81m/s^2

(b) A 150mm diameter shaft rotates at 1500 r.p.m in a 200mm long journal bearing, with an internal bearing diameter of 150.5 mm. The uniform annular space between the shaft and the bearing is filled with oil of dynamic viscosity 0.8 Poise. Calculate the power required to rotate the shaft.

3 + 9 = 12

B.TECH/AEIE/BT/CE/CHE/CSE/ECE/EE/IT/ME/2ND SEM/MECH 1201/2018

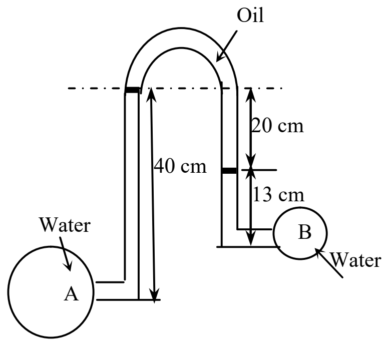
7. (a) In an air-standard Diesel cycle, at the beginning of compression process the working fluid is at 100 kPa, 27^{0}C. The maximum pressure in the cycle is 4MPa and the heat supplied during the cycle is 1000 kJ/kg. Determine (i) the compression ratio (ii) the temperature of air at the end of compression process, (iii) the cut-off ratio (iv) the thermal efficiency of the cycle.
For air, c_p = 1.005 kJ/kg-K; c_v = 0.718 kJ/kg-K; γ = 1.4; R = 0.287 kJ/kg-K.

(b) What is piezometric head? Show that the piezometric head in a static, incompressible fluid remain constant at all points in the fluid.

8 + (1 + 3) = 12

Group – E

8. (a) Water is flowing through two different pipes to which an inverted differential manometer having an oil of sp. gr. 0.85 is connected. The pressure head in the pipe A is 3 m of water. Find the pressure in pipe B for the manometer readings as shown in figure beside.



(b) Explain clearly what are meant by static pressure, dynamic pressure and stagnation pressure. Define and explain the difference between a streamline and a pathline.

6 + (3 + 3) = 12

9. (a) The velocity for a steady, incompressible fluid flow in the x-y plane is given by $\vec{V} = (A|x)\hat{\imath} + (Ay|x^2)\hat{\jmath}$; where $A = 4m^2/s$ and the coordinates are measured in meters. Obtain an equation for the streamline that passes through the point (x, y) = (1, 3).

(b) A vertical venturimeter carries water and has inlet and throat diameters of 150 mm and 75 mm respectively. The pressure connection at the throat is 250 mm above that at the inlet. If the actual rate of flow is 40 litre/sec and the coefficient of discharge is 0.96, calculate
(i) the pressure difference between inlet and throat, and
(ii) the difference in the levels of mercury in a vertical U-tube mercury manometer connected between these points, the tubes above the mercury being full of water.

3 + (6 + 3) = 12