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) As differentials, heat transfer and work transfer can be described mathematically as
(a) inexact (b) exact
(c) point function (d) discontinuity.

(ii) A thermodynamic system is referred to be an isolated system when there is transfer of _____ across the system boundaries [Fill up the blank]
(a) only mass (b) only energy
(c) both mass and energy (d) neither mass nor energy

(iii) Choose the open thermodynamic system from the following
(a) manual ice cream freezer (b) centrifugal pump
(c) pressure cooker (d) automobile storage battery.

(iv) In the context of a closed non flow system, the net energy transferred as heat and work equals the change in
(a) enthalpy (b) internal energy
(c) entropy (d) flow work.

(v) The efficiency of a Carnot Heat Engine with source and sink temperatures of 827°C and 227°C respectively is
(a) 45.5% (b) 54.5%
(c) 27.4% (d) 72.6%.

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

(vii) 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.

(viii) Material acceleration is zero for a flow which is
(a) steady (b) steady and uniform
(c) unsteady and uniform (d) steady and non-uniform.

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

(x) Streamlines, pathlines and streaklines refers to the Save Curve
(a) always (b) during uniform flow
(c) steady flow (d) when the convective acceleration is zero.

Group- B

2. (a) One kg of a certain fluid is contained in a horizontal cylinder fitted with a frictionless leak proof piston at a pressure of 10 bar. The fluid is allowed to expand reversibly in the cylinder until the volume becomes two times its original volume. During the expansion process, the relation between pressure and volume is given as $pv^2 = constant$. The fluid is then cooled reversibly at constant pressure until the piston regains its original position. Finally the fluid is heated reversibly with the piston firmly locked in position and the fluid pressure rises to initial value of 10 bar. If the fluid has an initial volume of 0.05 m^3, make calculations for the net work done by the fluid.

(b) Define specific heat at constant volume and constant pressure. Explain what is meant by a quasi-static process.

7+ (3 + 2) = 12

3. (a) A stationary mass of gas is compressed reversibly from an initial state (0.4 m^3, 0.1MPa) to a final state (0.2 m^3, 0.1MPa); the pressure remaining constant during the process. If there is a transfer of 15 kJ of heat from the gas during the process, evaluate the change in internal energy of the gas.

(b) Explain what is meant by a thermodynamic system and classify different thermodynamic systems. Define a PMM1. What is the converse of a PMM1**.**

6 + (4 + 2) = 12

Group- C

4. (a) Steam flows steadily into a condenser and at entry it has an enthalpy of 2050 kJ/kg and velocity of 500 m/s. The condensate (condensed steam) leaves with an enthalpy of 200 kJ/kg and velocity of 10 m/s. The exit from the condenser is

in line with the inlet. Determine the heat transfer to the cooling water per unit mass of steam.

(b) State Kelvin Planck statement of the second law of Thermodynamics and hence explain what is meant by a PMM2. Make an energy analysis of a steam turbine as a steady flow energy device.

6 + (3 + 3) = 12

5. (a) A reversible heat engine receives heat from two thermal reservoirs. One reservoir is maintained at constant temperatures of 750 K, while the other at 500 K. The engine develops 100 kW power 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 supply rates by each reservoir.

(b) A heat engine is supplied with 2512 kJ/min of heat at 650° C. Heat rejection takes place at 100° C. Indicate which of the following heat rejections represent a reversible, irreversible or impossible result:
(i) 867 kJ/min (ii) 1015 kJ/min (iii) 1494 kJ/min.

6 + 6 = 12

Group - D

6. (a) A heat engine draws in air at 1 bar and 300 K. Measurements indicate maximum pressure and temperature values to be 70 bar and 2000 K respectively. Determine the air standard efficiency if the engine works on diesel cycle. How does the efficiency compare with that of a Carnot cycle working within the same maximum and minimum temperature limits? How do you explain the difference between the two values?

(b) The velocity distribution $u(y)$ over a plate is given by $u(y) = \frac{2}{3}y - y^2$.
If μ (dynamic viscosity) = 0.754 Pa-s, find the shear stress at y = 0 and y = 0.15 m. [y is the height of fluid from the plate]

7 + 5 = 12

7. (a) A hydraulic ram of 200 mm diameter and 1.2 m long moves within a concentric cylinder of diameter 200.2 mm. The annular clearance is filled with oil of specific gravity 0.85 and kinematic viscosity 400 mm^2/s. What is the viscous force resisting the motion when the ram moves at a speed of 120mm/s. How much is the power required to drive the ram?

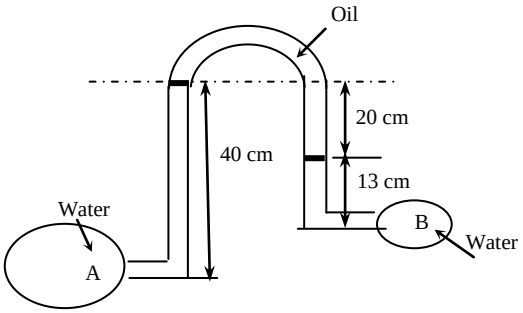
(b) Write short notes on:
Gauge pressure and vacuum pressure
No slip condition
Compressibility and coefficient of compressibility.

6 + 6 = 12

Group - E

8. (a) Water is flowing through two different pipes to which an inverted differential manometer with an oil as manometric fluid (specific gravity 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 below.



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

6 + (3 + 3) = 12

9. (a) Water flows up a vertical venturimeter whose inlet and throat diameters are 250 mm and 125 mm respectively, the throat section being 0.30 m above the inlet section. The pressure at the inlet and the throat sections are 60 kPa and 20 kPa respectively. Find the rate of flow through the meter. Take C_d = 0.98.

(b) Differentiate between a steady and uniform flow with example.
What is a turbulent flow as opposed to laminar flow? Write the expression of Reynolds number and specify the range of values for laminar/turbulent flow through a pipe

6 + (3 + 3) = 12