ENGINEERING THERMODYNAMICS AND 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) 1st law of Thermodynamics is essentially a conservation statement for
(a) mass (b) momentum
(c) energy (d) none of these.

(ii) A throttling process is a
(a) quasi-static process (b) reversible process
(c) constant internal energy (d) constant enthalpy process.

(iii) Zeroth law of Thermodynamics talks about a thermodynamic property which is
(a) internal energy (b) temperature
(c) enthalpy (d) entropy.

(iv) The following is an extensive property of a system
(a) temperature (b) pressure
(c) internal energy (d) specific volume.

(v) Identify the correct statement
(a) Heat and work are qualitatively same
(b) In a closed system, energy transfer cannot take place
(c) In a free expansion, work transfer is zero
(d) PMM 1 violates the zeroth law of Thermodynamics.

(vi) For a steady flow energy device, the property of the system within the device remains same with respect to
(a) time (b) space
(c) both time and space (d) none of these.

(vii) Specific internal energy of an ideal gas depends only on its
(a) mass (b) pressure
(c) specific volume (d) temperature.

(viii) Clausius equality is valid for
(a) a reversible cycle only (b) irreversible cycle only
(c) any cycle reversible or irreversible (d) none of these.

(ix) Ideal fluid is
(a) compressible with no viscosity (b) both compressible and viscous
(c) incompressible and viscous (d) incompressible and inviscid.

(x) The path traced by a single particle of smoke issuing out of cigarette smoke is a
(a) streamline (b) streakline (c) flow line (d) pathline.

Group - B

2. (a) What is meant by a thermodynamic system? Explain and classify different thermodynamic systems. Define a quasi static process.
(b) Obtain an expression for displacement work for a simple compressible system. What is meant by state function? Explain why work transfer is a path function.

5 + 7 = 12

3. (a) A piston-cylinder device operates with 1 kg of fluid at an initial pressure of 20 bar. The initial volume is 0.04 m^3. The fluid is allowed to expand reversibly following a process following the law $pv^{1.45} = constant$, so that the volume becomes double. The fluid is then cooled at constant pressure until the piston comes back to the original position. Keeping the piston unaltered, heat is added to restore the system to the initial pressure. (i) Show the cycle in the p-V diagram, (ii) calculate the individual work transfers in the different processes and (iii) the total work transfer in the cycle. Assume all the processes to be reversible.
(b) Describe with examples the meaning of a thermodynamic property. Distinguish between intensive and extensive properties. What is the difference between a homogeneous system and a heterogeneous system?

4 + 8 = 12

Group - C

4. (a) Explain the function of a nozzle as a steady flow device and obtain the expression of velocity with standard parameters.
(b) Air at a temperature of 150°C passes with a velocity of 30 m/s through a heat exchanger where its temperature is raised to 800°C. On leaving the heat exchanger with the same velocity, it enters into a turbine where it expands and the temperature falls to 650°C. The exit velocity of air from the turbine is 60 m/s. Flow rate of air is 2 kg/s. Calculate i) the rate of heat transfer to air in the heat exchanger ii) the power output from the turbine. Assume change in enthalpy of air due to change in temperature = $c_p \times \Delta T$. Given $c_p = 1.005$ kJ/kg.

6 + 6 = 12

5. (a) Make Kelvin Plank and Clausius statements of the 2nd law of thermodynamics. Define a cyclic heat engine with the help of a schematic diagram.

   (b) Two reversible heat engines **A** and **B** are connected in series. **A** receives heat from a source at 1200 K while **B** rejects heat to a sink at 300 K. Determine the intermediate temperature if (i) both of them produce the same work output (ii) both operate with same efficiency.

6 + 6 = 12

Group - D

6. (a) A diesel engine has a compression ratio of 14 and cut-off takes place at 6% of the stroke. Find the air standard efficiency. Given, $\gamma = 1.4$.

   (b) State Newton's law of viscosity and hence define dynamic viscosity. Obtain its dimension by dimension analysis. Two horizontal plates are placed 1.25 mm apart and the space between the plates is filled with an oil of viscosity of 5 poise. Compute the shear stress in the oil if the upper plate is moved with a velocity of 2.5 m/s.

6 + 6 = 12

7. (a) Define and explain the significance of the following in short:
   (i) air standard cycle (ii) piezometric head (ii) effect of temperature on viscosity.

   (b) A hydraulic lift used for lifting automobiles has 20 cm diameter ram that slides in 20.016 cm diameter cylinder. The annular space between the cylinder and ram is filled with an oil of kinematic viscosity 3.5 stokes and specific gravity 0.85. If the 3.2 m long ram is to travel at a uniform speed of 15 cm/s, determine the viscous resistance experienced by the ram.

6 + 6 = 12

Group - E

8. (a) Water flows through a pipe AB of 1.2 m diameter at 3 m/s and then passes through a pipe BC of diameter 1.5 m. At C, the pipe branches into CD and CE. Branch CD is of 0.8 m diameter and carries one third of the flow in AB. The flow velocity in branch CE is 2.5 m/s. Find (i) the volume flow rate in AB, (ii) the velocity in BC, (iii) the velocity in CD and (iv) the diameter of CE. Assume all the pipes to be horizontal.

   (b) The left limb of a vertical U-tube manometer is connected to the centre level of a horizontal pipe through which a fluid of specific gravity 0.85 flows. The right limb containing mercury (sp. Gr. = 13.6) is open to the atmosphere. The centre of the pipe lies 15 cm below the level of mercury of the right limb. If the difference between the mercury levels in the two limbs is 25 cm, determine the gauge pressure of the fluid flowing through the pipe.

6 + 6 = 12

9. (a) A pipe 300 m long has a slope of 1 in 100 and tapers from 1 m diameter at the high end to 0.5 m diameter at the low end. Quantity of water flowing is 5400 litres per minute. If the pressure at the high end is 70 kPa, find the pressure at low end.

(b) Briefly describe the function of an orificemeter and obtain an expression of flow rate.

6 + 6 = 12