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) Which of the following is an intensive property of a thermodynamic system?
(a) volume (b) temperature (c) mass (d) energy.

(ii) Work done in a free expansion process is
(a) positive (b) negative (c) zero (d) maximum

(iii) Stoke is the unit of
(a) Dynamic viscosity (b) Kinematic viscosity
(c) Surface tension (d) pressure.

(iv) Continuity equation is based on the principle of conservation of
(a) Mass (b) Momentum (c) Energy (d) Entropy

(v) During throttling process
(a) internal energy does not change (b) pressure does not change
(c) entropy does not change (d) enthalpy does not change.

(vi) A perpetual motion machine is
(a) a thermodynamic machine
(b) a non-thermodynamic machine
(c) a real machine
(d) a hypothetical machine whose operation would violate the laws of thermodynamics.

(vii) Kelvin-Planck's statement deals with
(a) conservation of energy (b) conservation of heat
(c) conservation of mass (d) conversion of heat into work

(viii) Internal energy of a perfect gas depends on
(a) temperature, specific heats and pressure
(b) temperature, specific heats and enthalpy
(c) temperature, specific heats and entropy
(d) temperature only.

(ix) A refrigerator and a heat pump, both reversible, operate between the same temperature limits. If the C.O.P of the refrigerator is 4, the C.O.P of the heat pump would be
(a) 3 (b) 4 (c) 5 (d) cannot be predicted.

(x) Turbulent flow through pipe occurs when Reynolds number (Re) is
(a) less than 2000 (b) between 2000 and 4000
(c) more than 4000 (d) less than 4000.

Group – B

2. (a) What is meant by a thermodynamic system and how are they classified? Explain the terms: state, path, and process in relation to Thermodynamics.
What is the zeroth law of thermodynamics?

(b) Explain the differences between a path function and a point function?
An ideal gas expands quasi-statically from a pressure P_1, volume V_1 to pressure P_2 and volume V_2 under isothermal condition. Deduce an expression of work done the gas.

(3 + 3) + (2 + 4) = 12

3. (a) What are +ve and –ve work interactions?
Obtain an expression of work in adiabatic expansion of an ideal gas with standard parameters.

(b) Define a thermodynamic cycle.
A non flow reversible process occurs for which pressure and volume are co-related by the equation $p = (V^2 + 6/V)$, where p is in bar and V is in m^3. What amount of work will be done when volume changes from 2 m^3 to 4 m^3?

(2 + 4) + (1 + 5) = 12

Group – C

4. (a) Water enters a boiler with enthalpy 150 kJ/kg and gets vapourised into steam with enthalpy 2825 kJ/kg. List down the appropriate assumptions to apply the steady flow energy equations to the boiler and work out the heat transferred per kg of steam to the device.
Explain what is meant by a nozzle.

(b) An ideal gas of volume 1.3 m^3 is compressed adiabatically from pressure 100 kPa and temperature 220 K to a final pressure of 400 kPa. Given c_p = 1.005 kJ/kg-K and c_v = 0.718 kJ/kg-K.
Find (i) adiabatic index (ii) final volume (iii) work done (iv) change in internal energy.

(4 + 2) + 6 = 12

5. (a) An engine mounted on a ship has a thermal efficiency 80% of that of the corresponding Carnot cycle. The engine receives heat from sea at 300 K and rejects heat to atmosphere at 280 K. The work output from the engine is

dissipated through an agitator to heat 500 kg of sea water to 355 K. What quantity of heat must be extracted from sea water for running the engine to produce the desired effect?
[specific heat of sea water c_p =4.186 kJ/kg-K]

(b) What is Clausius statement of the second law of thermodynamics?
Define a constant temperature thermal reservoir.
A reversed heat engine absorbs 250 kJ of heat from a low temperature region and takes 100 kJ of mechanical work input for its operation. What is the heat transferred to the high temperature region? Evaluate the COP of the reversed heat engine when working as a refrigerator and also as a heat pump.

6 + 6 = 12

Group – D

6. (a) Describe the various processes of an air standard Otto cycle with reference to a p-v diagram and obtain an expression of thermal efficiency with standard terms.

(b) In an air standard Otto cycle, the compression ratio is 6 and the isentropic compression begins at 100 kPa and 300 K. Heat is added at constant volume until pressure reaches a maximum of 3500 kPa.
Show the cycle schematically on p-v diagram. Calculate the temperature and pressure at the salient points. What is the efficiency of the cycle?

6 + 6 = 12

7. (a) State Newton's law of viscosity.
With a diagram explain velocity profile and velocity gradient.
Two horizontal and parallel plates are placed 1 cm apart with the space between them having been filled with lubricating oil (of viscosity 14 poise). Compute the shear stress developed on the plates if the upper plate is moved with a velocity of 2.5 m/s with the lower plate at rest.

(b) Measurements of pressure at the base and top of a mountain are 74 cm and 60 cm of mercury respectively. Work out the height of the mountain if air has a constant specific weight of 11.97 N/m^3.
A diver is working at a depth of 20 m below the surface of sea water (specific weight 10 kN/m^3) while the barometer reading nearby is 760 mm of mercury. Calculate the absolute pressure acting on the diver.

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

Group – E

8. (a) Define streamlines, pathlines and streaklines.
Water is flowing through a pipe of 0.5 m diameter with an average velocity of 1 m/s. What is the discharge (m^3/s) of water? The same flow then passes through another section where the diameter is 1 m. What is the average velocity through this section?

(b) What is the difference between a steady and uniform flow?
The following velocity components are involved in a fluid flow:
$u = (a_1x + b_1 y + c_1z)$, $v = (a_2x + b_2 y + c_2z)$, $w = (a_3x + b_3 y + c_3z)$;
where a_1, a_2 etc are constants. Under what conditions does the given velocity field represent an incompressible flow that conserves mass?

(3 + 3) + (2 + 4) = 12

9. (a) Make the mathematical statement of Bernoulli's equation with assumptions.
A horizontal water pipe of diameter 15 cm converges to a diameter of 7.5 cm. If the pressures at the two sections are 400 kPa and 150 kPa respectively, calculate the flow rate (m^3/s) of water.

(b) A pipeline carrying oil of specific gravity 0.87 changes in diameter from 200 mm at a position **A** to 500 mm at a section **B** which is 4 meters at a higher level. If the pressures at A and B are 1 bar and 0.6 bar respectively and the discharge is 0.2 m^3/s, determine the loss of head and the direction of flow (i.e., **A** to **B** or **B** to **A**).

(2 + 4) + 6 = 12

Department & Section	Submission Link
ME	https://forms.gle/D3AE4rPfpTUf5BP29 Google classroom code : buwknnn