WEST BENGAL UNIVERSITY OF TECHNOLOGY

ME-201

ENGINEERING THERMODYNAMICS & FLUID MECHANICS

Time Allotted: 3 Hours Full Marks: 70

The questions are of equal value.
The figures in the margin indicate full marks.
Candidates are required to give their answers in their own words as far as practicable.

GROUP A
(Multiple Choice Type Questions)

1. Answer *all* questions. $10 \times 1 = 10$

(i) For pipes, turbulent flow occurs when Reynolds number is
(A) less than 2000 (B) between 2000 to 4000
(C) more than 4000 (D) less than 4000

(ii) Thermal power plant works on
(A) Carnot cycle (B) Joule cycle (C) Rankine cycle (D) Otto cycle

(iii) The increase in temperature
(A) increase the viscosity of a liquid (B) decreases the viscosity of a liquid
(C) increases the viscosity of a gas (D) both (B) and (C)

(iv) Internal energy for gas in general can be written as

(A) $du = \left(\frac{du}{dt}\right)_v dt + \left(\frac{du}{dv}\right)_t dv$ (B) $du = \left(\frac{du}{dt}\right)_p dt + \left(\frac{du}{dv}\right)_t dv$

(C) $du = \left(\frac{du}{dt}\right)_t dt + \left(\frac{du}{dv}\right)_p dv$ (D) $du = \left(\frac{du}{dt}\right)_p dt + \left(\frac{du}{dv}\right)_v dv$

(v) Velocity potential exists for
(A) all 3-D flows (B) all irrotational flows
(C) all Newtonian fluid flow (D) steady irrotational only

(vi) Stoke is the unit of
(A) dynamic viscosity (B) kinematic viscosity
(C) both (A) and (B) (D) none of these

(vii) The household refrigerator operates in
(A) absorption refrigeration cycle
(B) cascade refrigeration
(C) reversed Carnot cycle
(D) ordinary vapour compression refrigerator cycle

(viii) The equation of a streamline passing through the origin in a flow field $u = \cos\theta$
(A) $y = x^3$ (B) $y = x\cos^2\theta$ (C) $y = x\tan\theta$ (D) $y = \sin\theta$

(ix) A flow is said to be steady when
(A) conditions change steadily with time
(B) conditions do not change with time at any point
(C) conditions do not change steadily with time at any point
(D) the velocity does not change at all with time at any point

(x) Which fluid does not experience shear stress during flow?
(A) Pseudo plastic (B) Dilatent (C) Invsicid (D) Newtonian

GROUP B
(Short Answer Type Questions)

Answer any *three* questions. $3 \times 5 = 1$

2. Consider a gas contained in a piston-cylinder assembly as the system. The gas is initially at a pressure of 5000kPa occupies a volume of 0.2 m^3. The gas is taken to the final state where pressure is equal to 100kPa by the following two different processes
(i) The volume of the gas is inversely proportional to the process.
(ii) The process follows the path pv^n = constant, where $n = 1.4$. Calculate the work done by the gas in each case.

3. (a) Prove that pressure (or intensity of pressure) at a point in a static fluid is equal in magnitude in all direction.

(b) The fluid flow velocity distribution over a flat plate is $u = 0.5y - y^2$ m which u is velocity in m/s at a distance y above the plate. Determine the shear stress at $y = 0.1$ m if the viscosity of the fluid is 5 poise. 2

4. (a) State Newton's law of viscosity? 2
(b) What is the effect of temperature on viscosity of liquid and that of gas? Explain your answer. 3

5. The diameters of a pipe at the sections 1 and 2 are 15 cm and 20 cm respectively. Find the discharge through the pipe if the velocity of water flowing through the pipe at section 1 is 8 m/s. Determine also the velocity at section 2. 5

6. Derive the relation between the performance parameter of a refrigerator and that of a heat pump. What is the advantage of using a heat pump over that of an electric resistance heater for heating purpose? 3+2

GROUP C
(Long Answer Type Questions)

Answer any *three* questions. 3×15 = 45

7. (a) What is bulk modulus elasticity? 2
(b) The space between two larger flat and parallel walls, 25 mm apart, is filled with a liquid of absolute viscosity of 0.7 N-s/ m^2. Within this space, a thin flat plate, 250 mm by 250 mm, is towed at a velocity of 150 mm / s at a distance of 6 mm from one wall, the plate and its movement being parallel to the walls. Assuming linear variations of velocity between the plate and the walls, determine the force exerted by the liquid on the plate. 10
(c) What is pure substance? 3

8. (a) Derive an expression for continuity equation for a three dimensional steady incompressible flow. 8
(b) The fluid flow is given by $\vec{v} = x^2 y\vec{i} + y^2 z\vec{j} - (2xyz + yz^2)\vec{k}$. Show that this is the case of possible steady 5 incompressible flow. Calculate the velocity and acceleration at (2, 1, 3) 4

(c) The velocity vector for a 2D uncompressible flow field is given by

$$\vec{v} = \left(\frac{x}{x^2 + y^2}\right)\vec{i} + \left(\frac{y^2}{x^2 + y^2}\right)\vec{j}$$

State whether the flow is continuous or discontinuous.

9. (a) Derive an expression for the discharge through an orifice meter.
(b) A horizontal orifice meter with orifice diameter 20 cm is inserted in a pipe of 30 cm diameter through which the water is flowing. Co-efficient of discharge for the orifice meter is 0.62. If the pressure gauges fitted up stream & down stream of the orifice meter show pressure 290 kN / m^2 & 195 kN / m^2 respectively. Find the discharge through the pipe.

10.(a) Draw the *P-V* and *T-S* diagram of Rankine cycle.
(b) Why is the Carnot cycle not practicable for a steam power plant?
(c) A thermal power plant is to be operated on an ideal Rankine cycle. Steam enters into the turbine at 2 MPa, 400°C and leaves as saturated liquid in the condenser at 10 KPa (0.01 MPa). The mass flow rate of steam is 1 kg/s. Find out the power developed by the turbine and the efficiency of the cycle. Assume the efficiencies of the turbine and the pump as 0.85 and 0.8 respectively.

Properties of Saturated water-Pressure base

		Volume(m^3/kg)		*Enthalpy(kJ/kg)*			*Entropy(kJ/kg-K)*		
P(MPa)	*Sat temp(°C)*	v_f	v_g	h_f	h_{fg}	h_g	s_f	s_{fg}	s_g
2	212.4	0.001177	0.0996	908.8	1890.7	2799.5	2.4478	3.8939	6.3417
0.01	45.8	0.001010	14.67	191.8	2392.8	2584.6	0.6491	7.5019	8.1510

Properties of Superheated Steam Table corresponding to 2 MPa and 400 °C

Volume(m^3/kg)	*Enthalpy(kJ/kg)*	*Entropy(kJ/kg-K)*
0.15120	3247.6	7.1271

11.(a) State the first law of thermodynamics for a closed system undergoing a cycle and a process.
(b) State the clausius inequality.
(c) Write the steady flow energy equation for a single stream entering and single stream leaving a control volume and explain the various terms.
(d) A gaseous system undergoes three quasi-static processes in sequence. The gas initially at 5 bar and 0.01 m^3 is expended at constant pressure. It is then further expended according to the relation $PV^2 = C$ to 2 bar and 0.025 m^3. The gas is then returned to its initial state during which process $PV = C$