MAULANA ABUL KALAM AZAD UNIVERSITY OF TECHNOLOGY, WEST BENGAL

Paper Code : ME-201

ENGINEERING THERMODYNAMICS & FLUID MECHANICS

Time Allotted : 3 Hours *Full Marks* : 70

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. Choose the correct alternatives for the following : $10 \times 1 = 10$

i) Which of the following is an intensive thermodynamic property ?

a) Volume b) Mass

c) Temperature d) Energy.

ii) The efficiency of a Carnot engine is 0·75. If cycle direction is reserved, COP of the reversed Carnot refrigeration cycle will be

a) 0·25 b) 1·25

c) 1·33 d) 0·33.

iii) Dynamic viscosity has dimension

a) MLT^{-2} b) $ML^{-1}T^{-1}$

c) $ML^{-1}T^{-2}$ d) $M^{-1}L^{-1}T^{-2}$.

iv) Euler's equation is written as

a) $\frac{dP}{\rho} + v^2 dv + g\,dz = 0$

b) $\frac{dP}{\rho} + v\,dv + g\,dz = 0$

c) $\frac{dP}{P} + v^2 dv + g\,dz = 0$

d) $\frac{dP}{\rho^2} + v^2 dv + g\,dz = 0$.

v) Which fluid does not experience shear stress during flow ?

a) Pseudo-plastic b) Dilatant

c) Inviscid d) Newtonian.

vi) A cycle consisting of two isentropic, one constant volume and one constant pressure processes is known as

a) Otto cycle b) Diesel cycle

c) Joule cycle d) Rankin cycle.

vii) If a heat engine attains 100% thermal efficiency, it violates the

a) zeroth law of thermodynamics

b) first law of thermodynamics

c) second law of thermodynamics

d) none of these.

viii) Internal energy of an ideal gas depend on its

a) temperature

b) pressure

c) volume

d) molecular weight and structure.

ix) For same maximum pressure, temperature and heat rejection for an otto and diesel cycle

a) otto cycle is more efficient

b) diesel cycle is more efficient

c) both are equally efficient

d) cannot be compared.

x) Pitot tube is used to measure

a) dynamic viscosity b) kinematic viscosity

c) mass diffusivity d) velocity of flow.

GROUP – B

(Short Answer Type Questions)

Answer any *three* of the following. $3 \times 5 = 15$

2. We propose to heat a house in the winter with a heat pump. The house is to be maintained at 20°C at all times. When the ambient temperature outside drops to –10°C, the rate at which heat is lost from the house is estimated to be 25 kW. What is the minimum electrical power required to drive the heat pump ?

3. a) What is the basic difference between a process and a cycle ? 2

b) Show that the work done in isothermal process from the state 1 to state 2 is given by

$$W_{1-2} = p_1 v_1 (\log_e p_1 - \log_e p_2)$$ 3

4. At the inlet to a certain nozzle the specific enthalpy of fluid passing is 2800 kJ/kg. The nozzle is horizontal and there is negligible heat loss from it. (i) Find the velocity at exit of the nozzle, (ii) If the inlet area is 900 cm^2 and specific volume at inlet is 0·187 m^3/kg, find the mass flow rate, (iii) If the specific volume at the nozzle exit is 0·498 m^3/kg, find the exit area of the nozzle.

5. The fluid flow is given $\vec{V} = x^2 yi + y^2 zj - (2xyz + yz^2)k$. Show that this is a case of possible steady incompressible flow. Calculate the velocity and acceleration at point (2, 1, 3).

6. a) State Newton's law of viscosity.

b) What are the causes of viscosity ?

c) What is no-slip condition ? $2 + 2 + 1$

GROUP – C

(Long Answer Type Questions)

Answer any *three* of the following. $3 \times 15 = 45$

7. a) A reversible heat engine operates between two reservoirs at temperature of 600°C and 40°C. The engine derives a reversible refrigerator operates between temperature 40°C and –20°C. The heat transfer to the heat engine is 2000 kJ and net work output of the combined engine refrigeration plant is 360 kJ.

i) Evaluate the heat transfer to the refrigerant and net heat transfer to the reservoir at 40°C

ii) Reconsider (i) given that the efficiency of the heat engine and COP of the refrigerator are each 40% of their maximum possible value. 8

b) One kg of ice at –3°C is exposed to the atmosphere which is at 20°C. The ice melts and comes into thermal equilibrium. Determine the entropy increases of the universe. C_p of ice = 2·093 kJ/kg-K and latent heat of fusion = 333·3 kJ/kg. 7

8. a) In an air standard diesel cycle, the compression ratio is 16, and at the beginning of isentropic compression, the temperature is 15°C and the pressure is 0·1 MPa. Heat is added until the temperature at the end of the constant pressure process is 1480°C. Calculate —

i) the cut-off ratio

ii) the heat supplied per kg of air

iii) the cycle efficiency. 8

b) Steam at 20 bar, 360°C is expanded in a steam turbine to 0·08 bar. It then enters a condenser, where it is condensed to saturated liquid water. The pump feeds back the water into the boiler. Assuming ideal processes, find per kg of steam the net work and the cycle efficiency. 7

9. a) Derive the Euler's equation. How can you obtain Bernoulli's equation from it ? 5

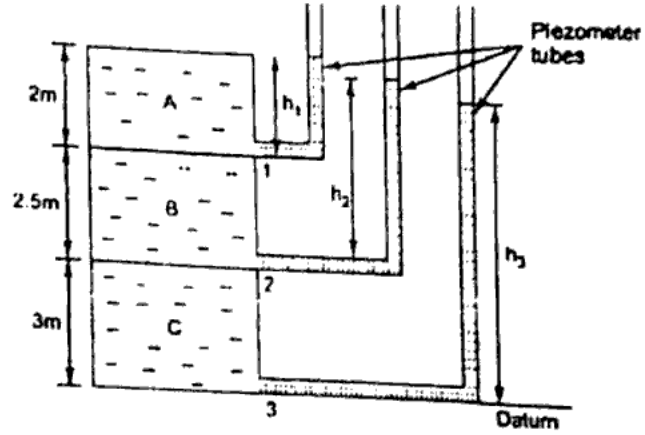
b) Classify various types of fluid with the help of Rheological diagram. 5

c) Water is flowing through a taper pipe of length 100 m having diameter 600 mm at upper end and 300 mm at the lower end at the rate of 50 ltr/s. The pipe has a slope of 1 in 30. Find the pressure at the lower end if the pressure at the higher end is 19·62 N/m^2. 5

10. a) A horizontal venturimeter with inlet and throat diameters 30 cm and 15 cm respectively is used to measure the flow of water. The reading of differential manometer connected to the inlet and the throat is 20 cm of mercury. Determine the rate of flow. Take Cd–0·98. 5

b) State Newton's law of Viscosity. 2

c) *A*, *B*, *C* are three liquids of specific gravity 0·8, 0·85 and 0·95 respectively. Calculate the height of liquid column in three piezometer tubes shown in figure below. Take datum as bottom line.3



8

11. a) A gas of mass 1·5 kg undergoes a quasi-static expansion which follows a relationship $p = a + bv$, where a and b are constants. The initial and final pressure is 1000 KPa and 200 KPa respectively and the corresponding volumes are 0·20 m^3 and 1·2 m^3. The specific internal energy of the gas is given by the relation.

U = 1·5 pv-85 kJ/kg

Where p is in KPa and v is in m^3/kg. Calculate the net heat transfer of the gas attained during expansion. 8

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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 v_1 = 512 kJ. The processes are as follows :

Process 1-2 : compression with $pv = c$ to p_2 = 2 bar and u_2 = 690 kJ.

Process 2-3 : $W_{23} = 0$, $Q_{23} = -150$ kJ

Process 3-1 : $W_{31} = +50$ kJ

Neglecting changes in K.E. and P.E. determine the heat interactions Q_{12} and Q_{31}. 7

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