2016

ENGINEERING THERMODYNAMICS & FLUID MECHANICS

(MECH 1201)

Time Alloted : 3 Hours *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 alternatives for the following : **[10×1=10]**

   i) Which of the following is not a point function?

   (a) Pressure (b) Volume

   (c) Internal Energy (d) Power

   ii) If P is a property of a system then which of the following is a wrong statement?

   (a) It has a unique value at a state.

   (b) $\oint dP = 0$.

   (c) P^2 may be taken as a new property.

   (d) P is a path.

iii) Entropy of an isolated system

(a) never decreases.

(b) never increases.

(c) never remains same.

(d) can increase or decrease.

iv) A carnot heat engine's efficiency increases from initial value 0.2 to final value 0.3, when the sink temperature reduces by 30K. The initial sink temperature is

(a) 200K (b) 240K (c) 300K (d) 360K

v) In air standard Diesel cycle, heat is added at constant

(a) pressure (b) volume

(c) temperature (d) entropy

vi) A Pitot Tube is an instrument, used in a fluid flow, essentially for the measurement of

(a) velocity at a point.

(b) pressure difference between two points.

(c) flow rate.

(d) all of these.

vii) SI unit of kinematic viscosity is :

(a) $N - s/m^2$ (b) m^2/s

(c) kg/m–s (d) Pa–s

viii) In a 2-D incompressible fluid flow, if u-th and v-th components of velocity in x and y direction are given by $u = cx + dy$ and $y = ax + by$, respectively, then for possible flow, the condition to be satisfied is

(a) $b + c = 0$ (b) $b + d = 0$

(c) $a + b + c + d = 0$ (d) $a + d = 0$

ix) Example of unsteady, uniform flow is the flow of a liquid at

(a) constant rate in a conically tapered pipe.

(b) constant rate in a straight pipe.

(c) variable rate in a conically tapered pipe.

(d) variable rate in a straight pipe.

x) Reynolds Number is defined as ratio of

(a) Inertia force to Gravity force

(b) Inertia force to Viscous force

(c) Inertia force to Pressure force

(d) Viscous force to Inertia force

GROUP - B

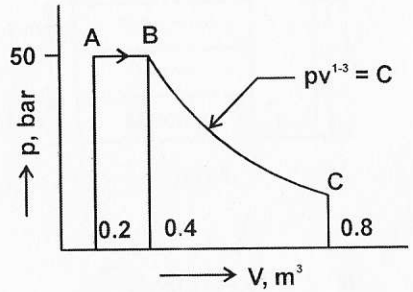
2. (a) What is the thermodynamic definition of work? A system of volume V contains a gas of mass m at pressure p and temperature T. The macroscopic properties of the system follow the relation : $(p + a/V^2)(V - b) = mRT$, where a, b and R are constants. Obtain an expression for the displacement work done by the system during a constant temperature expansion from volume V_1 to volume V_2.

(b) A system undergoes a process 1 – 2 in which it absorbs 200kJ energy as heat while it does 100kJ work. Then it follows path 2 – 3 in which it rejects 50 kJ energy as heat when 80kJ work is done on it. If it is required to restore the system from state 3 to state 1 through an adiabatic path, calculate the work and heat transfer along the path 3–1. Also calculate the net work and heat transfer during the cycle 1–2–3–1.

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

3. (a) Define thermodynamic property of a system. Make a Comparison of heat and work. If an adiabatic process in a control mass increases energy i.e. $E_2 - E_1 > 0$, what is the sign of W_{1-2}?

(b) Determine the total work done by a gas system following an expansion process along the path ABC as shown in the figure.



(2+2+2)+6 = 12

GROUP - C

4. (a) What is meant by a reversible process? Define the processes of a Carnot cycle and show the processes on a P–V diagram.

(b) A turbine operates under steady flow condition and receives steam at the following conditions:

Pressure = 1.2 MPa, Temperature = 188°C, Enthalpy = 2785kJ/kg, velocity = 33.3 m/s and elevation = 3m

Steam leaves the turbine at the following state :

Pressure = 20kPa, Velocity = 100 m/s, elevation = 0m, Enthalpy = 2512kJ/kg.

Heat is lost to the surroundings at the rate 0.29kJ/sec and the rate of steam flow through the turbine is 0.42kg/sec. What is the power output of the turbine in kW?

(2+4)+6 = 12

5. (a) Explain why heat transfer through finite temperature difference is irreversible. Determine which of the following is more effective way to increase the efficiency of a Carnot engine :

   (i) to increase T_1 keeping T_2 constant

   (ii) to decrease T_2 keeping T_1 constant?

   T_1 is the source temperature and T_2 is the sink temperature.

   (b) A heat pump is being used as a refrigerator as well. Establish the relationship between the COP's of the two when they are used in identical conditions.

(4+4)+4 = 12

Group - D

6. (a) (i) How does viscosity of fluid (liquid and gases) vary with temperature? State with reasons.

   (ii) What is no slip condition of viscous fluid?

   (b) A cylinder of 150mm radius rotates concentrically inside a fixed cylinder of 155mm radius. Both cylinders are 300mm long. Determine the viscosity of the liquid which fills the space between the cylinders if a torque of 0.98 N-m is required to maintain an angular velocity of 60 r.p.m.

2+2+8 = 12

7. (a) In a diesel engine, the compression ratio is 13:1 and fuel is cut off at 8% of the stroke. Find the air standard efficiency of the engine. Take γ = 1.4 for air.

   (b) Consider a tank containing Mercury, Water, Benzene and Air as shown in Fig. 1.

   Find the Air pressure (gauge) in the tank.

If an opening is made at the top of the tank, find the equilibrium level of the mercury in the manometer attached as shown. Specific gravity of Benzene = 0.879, Specific gravity of Mercury = 13.55

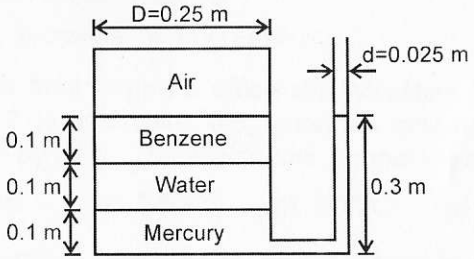


Fig.1.

6+(3+3) = 12

Group - E

8. (a) Derive the continuity equation in 3-D Cartesian co-ordinates.

   (b) For a flow in x-y plane, the y component of velocity is given by $v = y^2 - 2x + 2y$. Determine the expression of x-component of velocity (u), for a steady incompressible fluid flow, if u = 0, at x = 0.

6+6 = 12

9. (a) A fluid flow field has been given with velocity V = V(x, y, z, t) in Eulerian XYZ reference. Derive the expression for the total acceleration. What are meant by the local acceleration and convective acceleration?

   (b) The top and bottom diameter of a 2 m long vertical tapering pipe are 100 mm and 50 mm respectively. Water flows down the pipe at 30 litres per second. Find the pressure difference between the two ends of the pipe.

(5+2)+5 = 12