# ENGINEERING & MANAGEMENT EXAMINATIONS, JUNE – 2009

## MECHANICAL SCIENCE

### SEMESTER – 2

Time : 3 Hours ] [ Full Marks : 70

### GROUP – A

### ( Multiple Choice Type Questions )

1. Choose the correct alternatives for any *ten* of the following : $10 \times 1 = 10$

i) 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. ☐

ii) Thermodynamic system may be defined as a quantity of matter upon which attention is focused for study if

a) it is only bounded by real surface

b) the boundary surface is constant in shape and volume

c) it is not bounded by an imaginary surface

d) it is bounded by either real surface or imaginary surface, irrespective of shape or volume. ☐

iii) The expression $\int P\,dv$ may be applied for obtaining work of

a) non-flow reversible process

b) steady flow reversible process

c) steady flow non-reversible process

d) steady flow adiabatic reversible process. ☐

iv) The gas constant ( $R$ ) is equal to the

a) sum of two specific heats b) difference of two specific heats

c) product of two specific heats d) none of these.

v) Carnot cycle operates between the temperature of 1000 K and 500 K. Then the efficiency of the cycle is

a) 50% b) more than 50%

c) less than 50% d) none of these.

vi) In a reversible cycle, the entropy of the system

a) increases

b) decreases

c) does not change

d) first increases then decreases

e) depends on the properties of working substance.

vii) The latent heat of vaporisation at critical point is

a) less than zero b) greater than zero

c) equal to zero d) all of these.

viii) The work output of theoretical Otto cycle

a) increases with increase in compression ratio

b) increases with increase in pressure ratio

c) increases with increase in adiabatic index $Y$

d) follows all of these.

ix) Atmospheric pressure is

a) Gauge Pr. – Absolute Pr. b) Absolute Pr. – Gauge Pr.

c) Absolute Pr. – Vacuum Pr. d) Gauge Pr. + Vacuum Pr.

x) A differential manometer is used for measuring the

a) pressure at a point

b) velocity at a point

c) difference of pressure at two points

d) discharge. ☐

xi) Reynolds number is expressed as

a) $\rho \frac{VD}{\mu}$ b) $\frac{V^2 D}{\rho}$

c) $\frac{V\rho^2 D}{\nu}$ d) $\frac{V^2 D^2}{\nu}$. ☐

xii) During the throttling process

a) internal energy does not change

b) pressure does not change

c) entropy does not change

d) enthalpy does not change. ☐

## GROUP – B

### ( Short Answer Type Questions )

Answer any *three* of the following questions. 3 × 5 = 15

2. a) What is quality of wet steam ?

b) What is the difference between a refrigerator and a heat pump ?

Establish the relation : $COP_{HP} = COP_R + 1$. 2 + 3

3. Prove that entropy change for an ideal gas

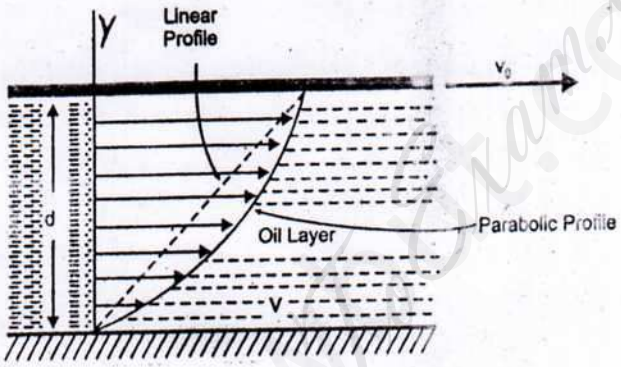
$$\int_1^2 ds = m C_v \ln\left(\frac{P_2}{P_1}\right) + m C_p \ln\left(\frac{V_2}{V_1}\right).$$ 5

4. A 0·025 $m^3$ vessel contains 0·3 kg of steam at 2 MPa. Determine the quality and enthalphy of steam. Given $t_s$ = 212·2° C, $V_f$ = 0·001177 $m^3$/kg, $V_g$ = 0·0995 $m^3$/kg, $h_f$ = 908·5 kJ/kg, $h_{fg}$ = 1888·7 kJ/kg, $S_f$ = 2·447 kJ/kg.K, $S_{fg}$ = 3·590 kJ/kg.K 5

5. State and prove Pascal's Law of Pressure at a point of a fluid body. 5

6. i) State Newton laws of viscosity.

ii) A large plate moves with speed $v_0$ over a stationary plate on a layer of oil. If the velocity profile is that of a parabola ( as shown in figure-1 ) with oil at the plates having the velocity as the plates, what is the shear stress on the moving plate from the oil ? 1 + 4




## GROUP – C

### ( Long Answer Type Questions )

Answer any *three* of the following questions. 3 × 15 = 45

7. a) Prove that $P_V = mRT$ where

$P$ = pressure

$V$ = volume of $m$ mass of gas

$T$ = temperature

$R$ = characteristic gas constant.

b) Write down the significance of universal gas constant ( $R_m$ ) and prove that $R = \frac{R_m}{M}$ where, $M$ = molecular weight of the substance.

c) When 0·1421 kg of a gas is heated from 27° C to 127° C and it is observed that the gas requires 202 kg of heat at constant pressure and 142 kJ of heat at constant volume. Find the adiabatic characteristic of gas constant and molecular weight of the gas. 4 + 2 + 4 + 5

8. a) What is a steady flow process ? Write the steady flow energy equation for a single steam entering and a single steam leaving a control volume and explain the various terms in it. Calculate work done from SFEE for turbine.

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

Pressure 1·2 MPa, Temperature – 188° C, Enthalphy 2785 kJ/kg, velocity 33·3 m/sec and elevation 3 m.

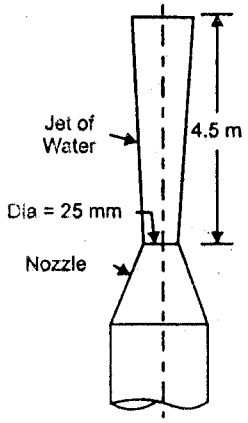
Steam leaves the turbine at the following state :

$P$ = 20 kPa, $V$ = 100 m/sec, enthalphy – 2512 kJ/kg and heat lost to the surrounding at the rate = 0·29 kJ/sec and the rate of steam flow through the turbine is 0·42 kg/sec. What is the power output of the turbine in kW ?

2 + 3 + 2 + 8

9. a) Derive an expression for continuity equation for a three dimensional steady incompressible flow.

b) A jet of water from a 25 mm diameter nozzle is directed vertically upwards, assuming that jet remains steady and neglecting any loss of energy. What will be the diameter at a point 4·5 m above nozzle, if the velocity with which jet leaves the nozzle is 12 m/sec ?



c) The velocity vector for a 2D incompressible flow field is given as $\vec{V} = \left(\frac{x}{x^2 + y^2}\right)\hat{i} + \left(\frac{y^2}{x^2 + y^2}\right)\hat{j}$. State whether the flow is continuous or discontinuous. 5 + 5 = 10

10. a) Draw the nature of *p-v* and *T-s* plots of a Rankine cycle ( with saturated steam at turbine inlet ).

b) A lump of steel of mass 15 kg at 557° C is dropped in 120 kg of oil at 25° C. The specific heats of steel and oil are 0·5 kJ/kg-K and 3·5 kJ/kg-K respectively. Calculate the entropy change of the steel, oil and the universe.

c) Two bodies each of equal mass $m$ and heat capacity $C$ are of temperature $T_1$ and $T_2$ $(T_1 > T_2)$ respectively. The first body is used as a source of reversible engine and the second as the sink. Show that the maximum work obtainable from such an arrangement is $m_c = \left(\sqrt{T_1} - \sqrt{T_2}\right)^2$. 4 + 5 + 1

11. a) Prove that $PV^\gamma$ = constant in adiabatic process and also prove $\frac{T_1}{T_2} = \left(\frac{P_1}{P_2}\right)^{\frac{\gamma-1}{\gamma}} = \left(\frac{V_2}{V_1}\right)^{\gamma-1}$.

b) What is cyclic heat engine ? Find the efficiency of heat engine in terms of source and sink temperature.

Which change is more effective to increase the efficiency of the engine.

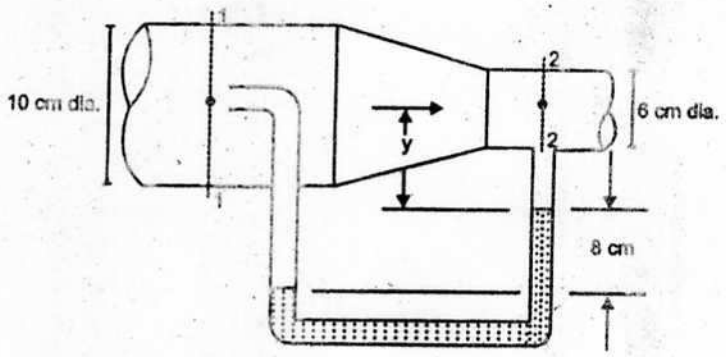
5 + 3 + 1 + 3 = 12

12. a) Derive an expression of actual discharge through a venturimeter tube.

b) Write Bernoulli's equation and describe the various terms in it.

What are the assumptions involved in derivation of Bernoulli's equation ?

c) In the figure, the fluid flowing in $(W_{air} = 12\,N/m^3)$ and the manometric fluid is Meriam Red oil ( specific gravity = 0·827 ). Assuming no loss, compute the flow rate.



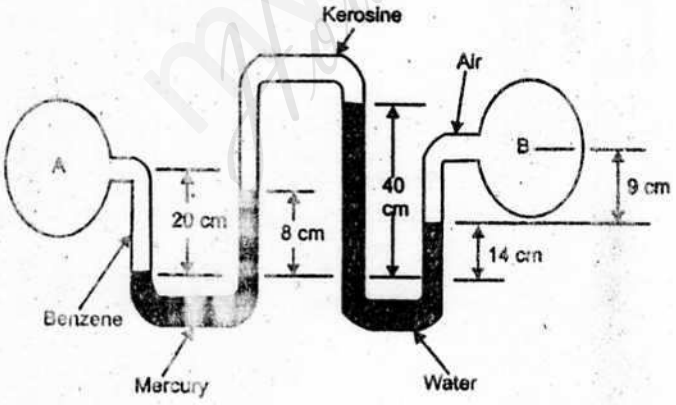

[Assuming $V_1 \ll V_2$]

5 + ( 3 + 2 ) + 5

13. a) Draw the rheological curve for a class of Newtonian and non-Newtonian fluid.

b) State and prove hydrostatic law of fluid. What is the stagnation pressure at a point in a fluid flow ?

c) Determine the pressure difference between points *A* and *B*. Specific gravities of benzene, kerosene and air are 0·88, 0·82 and $1·2 \times 10^{-3}$ respectively.




3 + 3 + 2 + 7

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