Name : .....

Roll No. : .....

Invigilator's Signature : .....

CS/B.Tech(OLD)/SEM-2/ME-201/2012

2012

MECHANICAL SCIENCE

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

   ii) The most effecitve way of increasing the efficiency of a Carnot engine is to
      a) increase higher temperature
      b) decrease higher temperature
      c) increase lower temperature
      d) decrease lower temperature.

iii) For a reversible adiabatic process, change in entropy is

a) maximum b) minimum

c) zero d) negative.

iv) An isentropic process on a T-S diagram is represented by a

a) horizontal line b) vertical line

c) inclined line d) curved line.

v) The first law of thermodynamics furnishes the relationship between

a) heat, work and properties of the system

b) various properties of the system

c) various thermodynamic processes

d) heat and internal energy.

vi) A stagnation point is a point in the fluid flow where

a) presure is zero

b) velocity is zero

c) total energy is zero

d) total energy is maximum.

vii) Streamline, path line and streak line are identical when the flow

a) is uniform

b) is steady

c) velocities do not change steadily with time

d) neither steady nor uniform.

viii) Bernoulli's theorem deals with the law of conservation of

a) mass b) momentum

c) energy d) force.

ix) An orifice meter is a device used to measure

a) temperature of fluid

b) pressure in a fluid

c) velocity at a point

d) flow rate.

x) Dynamic viscosity has dimensions as

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

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

GROUP – B

(Short Answer Type Questions)

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

2. a) State the first law of thermodynamics for

   i) a closed system undergoing a cycle

   ii) non-flow, non-cyclic process.

   b) What are the limitations of the first law of thermodynamics ? Illustrate with examples. 3 + 2

3. a) What is a basic difference between an open system and a closed system ?

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

   $$W_{1-2} = P_1 V_1 (ln P_1 - ln P_2).$$ 2 + 3

4. Define the coefficient of performance of a refrigerator and a heat pump. Explain why the performance of heat engines is measured in terms of efficiency but that of refrigerators and heat pumps in terms of COP. Establish the relation :

   $$COP_{HP} = COP_R + 1.$$ 2 + 2 + 1

5. Differentiate between the following : 1 + 1 + 1 + 1 + 1

   a) Ideal fluid and real fluid

   b) Newtonian and non-newtonian fluids

   c) Steamline and streak line

   d) Dynamic viscosity and kinematic viscosity

   e) Steady and unsteady fluids.

6. State and prove Pascal's law of pressure at a point of a static fluid. 1 + 4

7. a) Explain the terms 'saturation pressure' and 'saturation temperature'.

   b) What is quality or dryness fraction ? 3 + 2

GROUP – C
(Long Answer Type Questions)

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

8. a) Derive an expression for displacement work in process where pv^n = constant.

   b) Distinguish between an adiabatic system and isolated system.

   c) Show that internal energy is a propety of the system.

   d) A gas undergoes a thermodynamic cycle consisting of the following processes :

      i) Process 1 – 2 : Constant pressure P = 1·4 bar, V_1 = 0·028 m^3, W_{1-2} = 10·5 kJ.

      ii) Process 2 – 3 : Compression with PV = constant, $U_3 = U_2$.

      iii) Process 3 – 1 : Constant volume,

      $$U_1 - U_3 = -26{\cdot}4 \text{ kJ}.$$

   There are no significant changes in KE and PE. Sketch the cycle on the P-V diagram. Calculate the net work for the cycle in kJ. Also calculate the heat transfer for the process 1 – 2. 3 + 2 + 3 + 7

9. a) Derive the steady flow energy equation for a single stream entering and single stream leaving a control volume.

b) In a steam power station, steam flows steadily through a 0·2 diameter pipeline from a boiler to the turbine. At the boiler end the steam conditions are found to be :

p = 4 MPa, t = 400°C, h = 3213.6 kJ/kg and v = 0.073 m^3/kg. At the turbine end the conditions are found to be : p = 3.5 MPa, t = 392°C,

h = 3202.6 kJ/kg and v = 0.084 m^3/kg. There is a heat loss of 8.5 kJ/kg from the pipeline. Calculate the steam flow rate.

c) What are the basic components of a steam power plant working on a Rankine cycle ? 6 + 7 + 2

10. a) State and explain the Kelvin-Planck and clause statement of the second law of thermodynamics.

b) Prove that it is impossible to construct a heat engine which has higher efficiency than a irreversible heat engine operation between the same two thermal energy reservoirs.

c) Consider a heat engine that receives the heat at the rate of 1 MW at a high temperature of 550°C and rejects energy to the ambient at 27°C while work is produced at a rate of 450 kW. Find out how much heat is discarded to the ambient and the engine efficiency.

4 + 6 + 5

11. a) An engine working on the Otto cycle is supplied with air at 1 bar, 35°C. The compression ratio is 8. Heat supplied is 1500 kJ/kg. Calculate the maximum pressure and temperature of the cycle, the cycle efficiency and the mean effective pressure (for air, C_p = 1.005 kJ/kg-K, C_v = 0.718 kJ/kg-K, and R = 0.287 kJ/kg-K)

b) Consider 1 kg of ice at – 20°C as a system. It is exposed to the surroundings at 25°C. The ice melts to water ultimately coming to equilibrium with the surroundings. Calculate the entropy change of the system, the surroundings and the universe. Specific heats of ice and water are 2.1 kJ/kg-K and 4.2 kJ/kg-K respectively and the latent heat of fusion of ice is 333.5 kJ/kg. 8 + 7

12. a) Derive an equation for continuity equation for a three-dimensional flow.

b) A U-tube manometer is used to measure the pressure of the water in a pipe which is more than atmospheric pressure. The right arm of the manometer contains mercury and is open to the atmosphere. Determine the pressure in the pipe if the difference in the levels of the mercury in the limbs of U-Tube is 20 cm and free surface of the mercury is same with the centre of the pipe.

c) A 40 cm diameter pipe, conveying water, branches into two pipes of diameters 30 cm and 20 cm respectively. If the average velocity in the 40 cm diamter pipe is 3m/s, find the discharge in this pipe. Also determine the velocity in the 20 cm diameter pipe if the velocity in the 30 cm diameter pipe is 2m/s. 6 + 6 + 3

13. a) Write the Euler's equation of motion. Give the assumptions of Bernoulli's equation and derive the Bernoulli's equation for frictionless flow.

b) Water is flowing through the pipe having the diameters 100 mm and 50 mm at the bottom and upper ends respectively. The intensity of pressure at the bottom and the upper ends are 36 N/m^2 and 9·81 N/m^2. The rate of discharge through the pipe is 30 litres/s. Determine the difference in the datum head.

c) A verturimeter having the throat diameter of 150 mm is set in a vertical pipe with a 300 mm diameter to measure the discharge of an oil of specific gravity 0.85 which is flowing through the pipe in the upward direction. The difference in the elevations of the throat section and the entrance section of the venturimeter is 4 cm. The differential U-tube mercury manometer shows a difference of 25 cm. Take the coefficient of discharge of the venturimeter as 0.96. Calculate the discharge of oil flowing through the pipe. 3 + 6 + 6