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Candidate should write his/her Roll No. here.

Total No. of Questions : 7

No. of Printed Pages : 8

SEM-2016(03)-II
MECHANICAL ENGINEERING
Paper – II

Time : 3 Hours]

[Total Marks : 300

Instructions to the candidates :

Please read each of the following instructions carefully before attempting questions.

*Candidate should attempt **FIVE** questions in all.*

*Question No. 1 is **compulsory**. The remaining **FOUR** questions are to be attempted by selecting any four out of these six questions Q2 to Q7.*

All questions carry equal marks. The number of marks carried by a part of a question is indicated against it.

*Answer must be written in **ENGLISH** only. Unless otherwise mentioned, symbols and notations have their usual standard meanings. Assume suitable data, if necessary and indicate the same clearly.*

Neat sketches may be drawn, wherever required.

All parts and sub-parts of a question are to be attempted together in the answer book.

Any pages left blank in the answer book must be clearly struck out.

1. (a) Find the heat transferred to a gas of 2 kg when it is heated from 20 °C to 100 °C. The specific heat of gas at constant volume is given by

$$C_v = (0.5 + 0.005 T) \text{ kJ/kg } ^\circ\text{C}$$

also find out the mean value of specific heat.

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- (b) A stone of mass 10 kg and tank containing 100 kg water are initially at same temperature. A stone above 100 m falls into the water. Considering the stone and water as a system, determine ΔU , ΔPE , ΔKE ϕ and W , when

(i) the stone is about to enter the water

(ii) the stone has come to rest in the tank.

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- (c) In a flowing river a body is immersed at a depth of 3.5 m and the pressure on the upstream face of the body is found to be 35.30 kN/m².

Find the velocity of the river at that depth.

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- (d) If the velocity distribution in the boundary layer is given by $\frac{u}{v} = \frac{y}{s}$,

determine the displacement thickness, the momentum thickness and the energy thickness.

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- (e) The temperature distribution across a wall 1 m thick at a certain instant of time is given by

$$T(x) = a + bx + cx^2$$

while $a = 900\text{ }^{\circ}\text{C}$, $b = -300\text{ }^{\circ}\text{C/m}$ and $C = -50\text{ }^{\circ}\text{C/m}^2$.

A uniform heat generation $\dot{q} = 1000\text{ W/m}^3$ is present in the wall area of 10 m^2 having the property $K = 40\text{ W/m K}$. Determine the rate of heat transfer entering the wall ($x = 0$) and leaving the wall ($x = 1\text{ m}$). Also calculate the rate of change of energy storage in wall.

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- (f) A system for heating water from an inlet temperature of $20\text{ }^{\circ}\text{C}$ to an outlet temperature of $60\text{ }^{\circ}\text{C}$ involves passing the water through a thick walled tube having inner and outer diameters of 20 and 40 mm. The outer surface of the tube is well insulated and electrical heating within the wall provides for a uniform generation of heat of $\dot{q} = 10^6\text{ W/m}^3$. For a water mass flow rate of $\dot{m} = 0.1\text{ kg/s}$, how long must the tube be to achieve the desired outlet temperature?

Take $C_p = 4179\text{ J/kg} \cdot \text{K}$.

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- (g) An engine working on otto-cycle has a volume of 0.5 m^3 pressure 1 bar and temperature of $27\text{ }^{\circ}\text{C}$ at the beginning of the compression stroke. At the end of the compression stroke, the pressure is 10 bar, 210 kJ of heat is added during constant volume heating process. Calculate the pressures, temperatures and volumes at salient points in the cycle.

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- (h) For a vapour compression refrigeration system, sketch p-h diagram on T-S diagram and express the coefficient of performance of the cycle in terms of enthalpies. 6
- (i) Explain any three geometry statements and three motion statements in APT language. 6
- (j) Explain the general application characteristics in an environment of material handling by robots. 6
2. (a) Three pipes of same length L , diameter D and friction factor f are connected in parallel. Determine the diameter of the pipe of length L and friction factor f which will carry the same discharge for the same head loss. Use the formula $b_f = \frac{f \times L \times V^2}{2gD}$ 30
- (b) Oil with a free stream velocity of 2 m/sec flows over a thin plate 2 m wide and 2 m long. Calculate the boundary layer thickness and the shear stress at the trailing end point and determine the total surface resistance of the plate. Take specific gravity as 0.86 and kinematic viscosity as $10^{-5} \text{ m}^2/\text{sec}$. 30
3. (a) 0.5 kg of air, initially at 25°C is heated at constant pressure until the volume is doubled and is then heated at constant volume until the pressure is doubled. For the total path, find the work transfer, heat transfer and change in entropy. 30

- (b) A plane wall is a composite of two materials A & B. The wall of material A has uniform heat generation $\dot{q} = 1.5 \times 10^6 \text{ W/m}^3$, $K_A = 75 \text{ W/m} \cdot \text{K}$ and thickness $L_A = 50 \text{ mm}$. The wall material B has no generation with $K_B = 150 \text{ W/m} \cdot \text{K}$ and thickness $L_B = 20 \text{ mm}$. The inner surface of material A is well insulated, while the outer surface of material B is cooled by a water stream with $T_\infty = 30^\circ\text{C}$ and $h = 1000 \text{ W/m}^2 \cdot \text{K}$. Determine the temperature T_0 of the insulated surface and the temperature of T_2 of the cooled surface.

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4. (a) Two large parallel planes having emissivities of 0.3 and 0.5 are maintained at 800°C and 350°C respectively. A radiation shield having an emissivity of 0.05 on both sides is placed between the two planes, calculate

- (i) heat transfer per m^2 without shield
- (ii) the temperature of shield and
- (iii) heat transfer per m^2 with shield.

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- (b) A vapour compression cycle with ammonia as refrigerant works between the limits of saturated suction temp. of -20°C and saturated condensing temp. of 30°C . It is a simple saturated cycle and compression is isentropic, determine the work of compression per kg of ammonia. Compare the same if ammonia vapours leaving the evaporator at -20°C is absorbed by water so that the mass concentration in the solution reaches about 40% and its solution is pumped to the condenser pressure. Assume specific volume of solution to be $0.001161 \text{ m}^3/\text{kg}$. Assume $h_2 = 1420 \text{ kJ/kg}$ and $h_3 = 1668 \text{ kJ/kg}$. (p-h chart values)

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5. (a) During the test on 4-cylinder, 4-stroke petrol engine, the following readings are taken :

Diameter of the cylinder = 80 mm, stroke of the piston = 100 mm. Speed of the engine = 3000 rpm, Load on the hydraulic dynamometer = 160 N, Dynamometer constant = 20420 when speed is in rpm. Fuel consumption = 8 kg/hr. C_v of the fuel used = 43000 kJ/kg. The temperature and pressure of the charge at the end of suction stroke = 15 °C and 1 bar.

A : F ratio = 13 : 1.

For the determination of the mechanical efficiency of the engine, a Morse test was carried out by shorting the spark plugs of each cylinder successively without change of speed. The corresponding BP's of the engine are 16.5, 16, 15.6 and 17.6 kW respectively.

Determine

- (i) The BP, Brake mean effective pressure and Brake thermal efficiency of the engine.
- (ii) Also find the mechanical efficiency and volumetric efficiency of the engine at suction condition.

(30 + 20)

- (b) A gas turbine plant operates on Brayton cycle between temp. limit of 1100 °K and 310 °K. Calculate the maximum work done per kg of air (kJ/kg) and corresponding cycle efficiency.

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6. (a) A Kaplan turbine develops 24647.6 kW power at an average head of 39 metres. Assuming a speed ratio of 2, flow ratio of 0.6, diameter of the boss equal to 0.35 times the diameter of the runner and an overall efficiency of 90%. Calculate the diameter, speed and specific speed of the turbine.

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- (b) A simple turbo-jet unit operates with a turbine inlet temperature of 1100 K, a pressure ratio is 4 : 1 and air mass flow of 22.7 kg/sec under design conditions. The following component efficiencies may be assumed :

Isentropic compressor efficiency – 0.85

Isentropic turbine efficiency – 0.90

Propelling nozzle efficiency – 0.95

Transmission efficiency – 0.99

Combustion chamber pressure loss – 0.21

Calculate the design thrust and specific fuel consumption when the unit is stationary at sea-level where the ambient condition may be taken as 1.013 bar and 288 K

$$C_{pa} = 1.0035, \gamma_{air} = 1.4$$

$$C_{pg} = 1.147, \gamma_{gas} = 1.33$$

L.C.V. of the fuel = 43125 kJ/kg · K.

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7. (a) Explain the working of Raster Scan (Digital TV) as a graphics terminals for CAD 15
- (b) Explain the relationship of adoptive control machining in computer aided manufacturing. 15
- (c) The work table of a positioning system is driven by a lead screw having pitch = 6 mm. The lead screw is connected to the output shaft of stepper motor through a gearbox whose ratio is 8 : 1. The stepper motor has 72 step angles. The table must move a distance of 240 mm from its present position at a linear velocity of 540 mm/min. Determine the no. of pulses required to move the table and required motor speed. 30
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