SEAL

Roll No.

700095

Candidate should write his/her Roll No. here.

Total No. of Questions : **7**

No. of Printed Pages : **7**

SEM–2017(03)–II

MECHANICAL ENGINEERING

Paper—II

Time : **3** Hours]

[*Total Marks* : **300**

Instructions to the candidates :

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

Candidates 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.

Answers 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.

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1. *(a)* In new temperature scale say °ρ, the boiling and freezing points of water at 1 atmosphere pressure are 100° and 300° respectively. Correlate this scale with centigrade scale. Find the value of 0 °ρ on the centigrade scale at 1 atmospheric pressure. 6

(b) A reversible heat engine receives 6 kJ of heat from the thermal reservoir at 800 K and 8 kJ of heat from another thermal reservoir at temperature of 600 K. If it rejects heat to a third thermal reservoir at a temperature of 100 K, find the thermal efficiency of the engine. 6

(c) For the maximum transmission of power through a pipeline with total head *H*, find the value of total head loss due to friction h_f in terms of *H*. 6

(d) The sling psychrometer that is used to measure the condition of moist air gives the following readings : 6

> Dry-bulb temperature (DBT) = 35 °C, P_{vs}/DBT—saturation pressure at dry-bulb temperature is ·0563 bar, wet-bulb temperature (WBT) = 25 °C, P_{vs}/WBT—saturation pressure at wet-bulb temperature is ·0317 bar.

Calculate specific humidity and vapor density of the air.

(e) A counterflow shell and tube heat exchanger are used to heat water with hot exhaust gases.The water (C_p = 4180 J/kg-°C) flows at the rate of 2 kg/s while the exhaust gas (C_p = 1030 J/kg-°C) flows at the rate of 5·25 kg/s. If the heat transfer surface area is 32·2 m^2 and the overall heat transfer coefficient is 200 W/m^2-°C, find NTU of heat exchanger. 6

(f) A solid copper ball of mass 500 grams when quenched in a very large size water bath at 30 °C, cools from 530 °C to 430 °C in 10 seconds. Find the temperature of the ball in next 10 seconds. 6

(g) The working temperatures in the evaporator and condenser coils of the refrigerator are –30 °C and 32 °C respectively. If the actual refrigerator has a COP of 0·75 of the maximum, find the required power input for a refrigerating effect of 5 kW. 6

(h) A 40 kW engine has a mechanical efficiency of 80%. If the frictional power is assumed to be constant with load, what is the approximate value of the mechanical efficiency at 50% of the rated load? 6

(i) In a gas turbine, hot combustion products with the specific heats $C_p = 0 \cdot 98$ kJ/kgK and $C_v = 0 \cdot 7538$ kJ/kgK, enter the turbine at 20 bar and 1500 K and exit at 1 bar. The isentropic efficiency of the turbine is 0·94. Find the work developed by the turbine per kg of gas. 6

(j) Compare NC and CNC machines on the basis of different parameters. 6

2. (a) Two identical bodies of constant heat capacity are at the same initial temperature T_i. A refrigerator operates between these two bodies until one body is cooled to temperature T_2. If the bodies remain at constant pressure and undergo no change of phase, show that the minimum amount of work needed to do this work is

$$W_{(\min)} = C_p \left(\frac{T_i^2}{T_2} + T_2 - 2T_i \right)$$

30

(b) The internal energy of air is given by

$$u = u_0 + 0 \cdot 718t$$

where u is in kJ/kg, u_0 is any arbitrary value of u at 0 °C in kJ/kg and t is the temperature in °C. Also for air $P_v = 0 \cdot 287(t + 273)$, where p is in kPa and v is in m^3/kg.

A mass of air stirred by a paddle wheel in an insulated constant volume tank. The velocities due to stirring make a negligible contribution to the internal energy of the air. Air flows out through a small valve in the tank at a rate controlled to keep the temperature in the tank constant. At a certain instance, the conditions are as follows :

Tank volume 0·12 m^3, pressure 1 MPa, temperature 150 °C, and power to paddle wheel 0·1 kW.

Find the rate of flow of air out of the tank at this instant. 30

3. *(a)* Two parallel plates kept 0·1 m apart have laminar flow of oil between them with a maximum velocity of 1·5 m/s. Calculate the discharge per metre width, the shear stress at the plates, the difference in pressure in pascals between two points 20 m apart, the velocity gradient at the plates and velocity at 0·02 m from the plate. Take viscosity of oil to be 2·453 N.s/m^2. 30

(b) Air flows over a flat plate 1 m long at a velocity of 6 m/s.

Determine—

(i) the boundary layer thickness at the end of the plate;

(ii) shear stress at the middle of the plate;

(iii) total drag per unit length on the sides of the plate.

Take $\rho = 1 \cdot 226$ kg/m^3 and $\upsilon = 0 \cdot 15 \times 10^{-4}$ m^2/s for air. 30

4. *(a)* An inward flow reaction turbine discharges radially and the velocity of flow is constant and equal to the velocity of discharge from the turbine. Show that the hydraulic efficiency can be expressed by

$$h = \frac{1}{1 + \dfrac{\dfrac{\tan^2 \alpha}{2}}{\left(1 - \dfrac{\tan \alpha}{\tan \theta}\right)}}$$

where α and θ are respectively the guide vane angle and wheel vane angle at inlet. 30

(b) The temperature limits of an NH_3 refrigeration system are 25 °C and −10 °C. If the refrigerator is dry saturated at the end of compression and the refrigerant leaves as saturated liquid at the end of condenser, calculate COP. Use the following table :

t (°C)	h_f (kJ/kg)	LH (kJ/kg)	s_f (kJ/kg-K)
25 °C	298·9	1166·94	1·1242
−10 °C	135·37	1297·68	0·5443

where,

h_f—enthalpy of saturated liquid (kJ/kg)

LH—latent heat of vaporization (kJ/kg)

s_f—entropy of saturated liquid (kJ/kg-K) 30

5. (a) A gas turbine plant's turbine and compressor isentropic efficiencies are 85% and 86%. The maximum cycle temperature is 875 °C. The working fuel can be taken as air ($C_p = 1$ kJ/kgK and $\gamma = 1\cdot4$), which enters the compressor at 1 atm pressure and 27 °C. The pressure ratio is 4. The fuel used has a calorific value of 42000 kJ/kg. There is a loss of 10% calorific value in the combustion chamber. Calculate the thermal efficiency and air fuel ratio of the gas turbine plant. 30

(b) An adiabatic steam turbine receives dry-saturated steam at 1 MN/m^2 and discharges it at 0·1 MN/m^2. The steam flow rate is 3 kg/s and the moisture at exit is negligible at the ambient temperature. Calculate the power output of the turbine and its isentropic efficiency. 30

Properties of steam are given below :

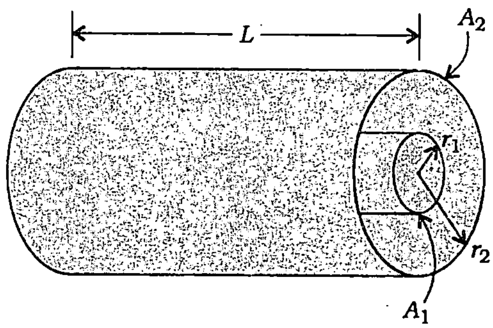
P_{sat} (MN/m^2)	T_{sat} (°C)	h_f (kJ/kg)	h_g (kJ/kg)	s_f (kJ/kg-K)	s_g (kJ/kg-K)
1·0	179·9	762·8	2778·7	2·139	6·586
0·1	99·6	417·5	2675·5	1·303	7·359

where f—saturated liquid, g—saturated vapor.

6. *(a)* Two concentric cylinders having diameters of 10 cm and 20 cm have a length of 20 cm. Calculate the shape factors between the open ends of cylinders. Given that

$$F_{21} = 0 \cdot 4126$$

$$F_{22} = 0 \cdot 3286$$



where 1 stands for inner cylinder and 2 stands for outer cylinder. 30

(b) Hot water at 98 °C flows through a 2-in schedule 40 horizontal steel pipe [k = 54 W/m °C] and is exposed to atmospheric air at 20 °C. The water velocity is 25 cm/s. Calculate the overall heat-transfer coefficient for this situation, based on the outer area of pipe.

Given that, the dimensions of 2-in schedule 40 pipe are

ID = 2·067 in = 0·0525 m

OD = 2·375 in = 0·06033 m

Properties of water at 98 °C : ρ = 960 kg/m^3, μ = 2·82 × 10^{-4} kg/m-s, k = 0·68 W/m °C, Pr = 1·76. 30

7. *(a)* Explain in detail about the thermodynamic, chemical and physical requirements of a refrigerant. Also write the chemical formula of following refrigerants : 20

(i) R-12

(ii) R-114

(iii) R-134

(iv) R-718

(b) Explain different types of industrial robots in detail with neat sketches. 20

(c) What do you understand by automated material handling system? Explain in detail about different types of material handling devices used in manufacturing industries. 20

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