CBCS SCHEME

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18MT72

Seventh Semester B.E. Degree Examination, Jan./Feb. 2023
Thermal Engineering

Time: 3 hrs. Max. Marks: 100

Note: 1. Answer any FIVE full questions, choosing ONE full question from each module.
2. Use of Heat transfer handbook is permitted.

Module-1

1 a. Define the following with examples:
(i) Open system (ii) Closed system (iii) Path function
(iv) Point function (v) Intensive properties **(10 Marks)**

b. Explain Quasi-static process with a neat sketch. **(05 Marks)**

c. State the zeroth law of thermodynamics. Explain thermodynamic equilibrium. **(05 Marks)**

OR

2 a. Distinguish between thermodynamic heat and work. **(08 Marks)**

b. Compute the work done by 1 kg of a fluid system as it expands slowly behind a piston from an initial pressure of 6×10^5 Pa and initial volume of 0.06 m^3 to a final volume of 0.18 m^3 in the following process :
(i) Pressure remains constant.
(ii) Volume remains constant.
(iii) $P\nu^{1.3}$ = constant **(06 Marks)**

c. A spherical ballon of 1 m diameter contains a gas at 200 kPa. The gas inside the ballon is heated until the pressure reaches 500 KPa. During the process of heating the pressure of the gas inside the ballon is proportional to the cube of the diameter of the ballon. Determine the work done by the gas inside the ballon. **(06 Marks)**

Module-2

3 a. State the 1st law of thermodynamic for a cyclic process and show that internal energy is a property of a system. **(10 Marks)**

b. State the 1st law for a closed system undergoing a change of state. **(05 Marks)**

c. What are the modes in which energy is stored in a system? **(05 Marks)**

OR

4 a. Explain Carnot's reversible heat engine with figure. **(05 Marks)**

b. Explain thermodynamic temperature scale. **(05 Marks)**

c. A reversible engine operates between temperatures T_1 and T (T_1>T). The energy rejected from this engine is received by a second reversible engine at the same temperature T. The second engine rejects energy at temperature T_2(T_2<T).
Show that
(i) Temperature T is the arithmetic mean of temperature T_1 and T_2 , if the engine produces the same amount of work output.
(ii) Temperature T is the geometric mean of temperature T_1 and T_2 if the engines have the same cycle efficiencies. **(10 Marks)**

Module-3

5 a. Explain dual cycle driving an expression for its efficiency. **(10 Marks)**

b. An engine working on the otto cycle is supplied with air at 0.1 MPa, 35˚C. The compression ratio is 8. Heat supplied is 2100 kJ/kg. Calculate the maximum pressure and temperature of the cycle, the cycle efficiency and the mean effective pressure.
(For air, $C_P = 1.005$, $C_V = 0.718$ and R = 0.287 kJ/kgK) **(10 Marks)**

OR

6 a. Explain the modes of heat transfer with governing law and equation. **(10 Marks)**

b. Describe boundary conditions of 1^{st}, 2^{nd} and 3^{rd} kind with figure. **(10 Marks)**

Module-4

7 a. The temperature distribution across a large concrete slab 50 cm thick heated from one side as measured by thermo couples approximate to the relation.

$T = 60 - 50x + 12x^2 + 20x^3 - 15x^4$

Where T is in ˚C and x is in meter considering area of 5 cm^2. Compute

(i) Heat entering and leaving the slab.

(ii) Heat energy stored in unit time for concrete K = 1.2 W/mK. **(10 Marks)**

b. A composite slab is made of two layers of different materials A and B such that, layers A has conductivity as $K_A = 0.5(1+0.008T)$ and is 5 cm thick, while the layer B has conductivity 24 W/mK and is 2 cm thick. The exposed surface of layer A is insulated while that of the layer B is exposed to the fluid at 20˚C where the heat transfer co-efficient is 30 W/m^2K. If the temperature at the interface between the two layers is 80˚C, find

(i) Rate of heat flux from slab to the fluid.

(ii) Maximum temperature in the system.

(iii) The distance of a point at 80˚C from insulated surface. **(10 Marks)**

OR

8 a. A square plate $40\text{ cm} \times 40\text{ cm}$ maintained at 400 K is suspended vertically in atmospheric air at 300 K.

(i) Determine the boundary layer thickness at trailing edge of the plate.

(ii) Calculate the average heat transfer co-efficient using a relation.

$N_u = 0.516(G_{rL}.P_r)^{0.25}$

Take the following properties of air,

$V = 20.75\times10^{-6}\ m^2/s$; K = 0.03 W/m-K ; $\beta = 2.86\times10^{-3}\ K^{-1}$, $P_r = 0.7$ **(10 Marks)**

b. A thin 20 cm diameter horizontal plate is maintained at 120˚C in a large body of water at 80˚C. The plate converts heat from its top and bottom surfaces. Determine the rate of heat input to the plate necessary to maintain the temperature of 120˚C. **(10 Marks)**

Module-5

9 a. Hydrogen at 9˚C and at a pressure at 1 atm, is flowing along a flat plate at a velocity of 3 m/s, If the plate is 0.3 m wide and at 45˚C. Calculate the following quantities at x = 0.3 m and at the distance corresponding to the transition point, i.e. $R_{ex} = 5\times10^5$.

(i) Hydrodynamic boundary layer thickness.

(ii) Local friction co-efficient.

(iii) Average friction coefficient.

(iv) Thickness of thermal boundary layer in cm.

(v) Drag force.

(vi) Local convective heat transfer co-efficient.

(vii) Average convective heat transfer co-efficient.

(viii) Rate of heat transfer. **(16 Marks)**

b. Explain physical significance of Reynold's number and Prandtl number. **(04 Marks)**

OR

10 a. Two concentric cylinders having diameters of 10 cm and 20 cm have a length of 20 cm. Calculate the radiation shape factor between the open ends of the cylinders. **(10 Marks)**

b. Two large parallel plates are at 1000˚K and 800˚K. Determine the heat exchange per unit area where

(i) The surface are black.

(ii) The hot surface has an emissivity of 0.9 and cold 0.6.

(iii) A large plate of emissivity 0.1 is inserted between them.

Also find the percentage reduction in heat transfer because of introduction of the large plate. **(10 Marks)**

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