5E3176-Q

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B. Tech. (Sem. V) (Main) Examination, December - 2011
Mechanical Engg.
5ME2 Heat Transfer

Time : 3 Hours] [Maximum Marks : 80
[Min. Passing Marks : 24

Instructions to Candidates :

*Attempt any **five questions** selecting **one question** from **each unit**. All questions carry **equal** marks. Schematic diagrams must be shown wherever necessary. Any data you feel missing suitably be assumed and stated clearly. Units of quantities used/calculated must be stated clearly.*

Use of following supporting material is permitted during examination.
(Mentioned in form No. 205)

1. NIL 2. NIL

UNIT - I

1 (a) Develop general heat conduction equation in cartesian coordinates. Deduce the developed equation for the following cases :

(i) Constant thermal conductivity

(ii) no heat generation

(iii) Steady state condition and

(iv) Steady state conduction with no heat generation

(b) Define and discuss thermal diffusivity.

12+4

OR

1 (a) (i) What do you mean by critical thickness of insulation?

(ii) A cylindrical pipe of 20 mm outer diameter is to be insulated so that the heat loss from the pipe is not more than 65 w per m length. The pipe surface temperature is 280°C and it can be assumed that the pipe surface temperature remains the same after application of insulation layer. The surrounding temperature is 30°C. The heat transfer coefficient from the surface is 10 W/m^2 °C. Insulation materials available for the service are asbestos (k = 0.14 W/m°C) and slag wool (k = 0.08 W/m °C). Determine thickness of these insulations and comment on the result.

2+6

(b) The wall of a furnace is built up of a 250 mm thick layer of fire clay bricks whose thermal conductivity is given by

$k = 0.83\ (1+0.0007\ t)$ W/m °C

Calculate the rate of heat loss per m^2 of the wall surface if the temperature of the gas in furnace is 1200°C and the ambient temperature is 20°C. The film coefficients of heat transfer from inner and outer wall surface are 30 W/m^2 °C and 20 W/m^2 °C, respectively.

8

UNIT - II

2 (a) Define fin efficiency and effectiveness. Discuss effect of different fin parameters on them.

4

(b) Derive the expression for temperature distribution and heat flow for a very long fin.

8

(c) Write down nodal equation for point 1 for the case of two-dimensional steady-state conduction for the cases shown in Fig.1.

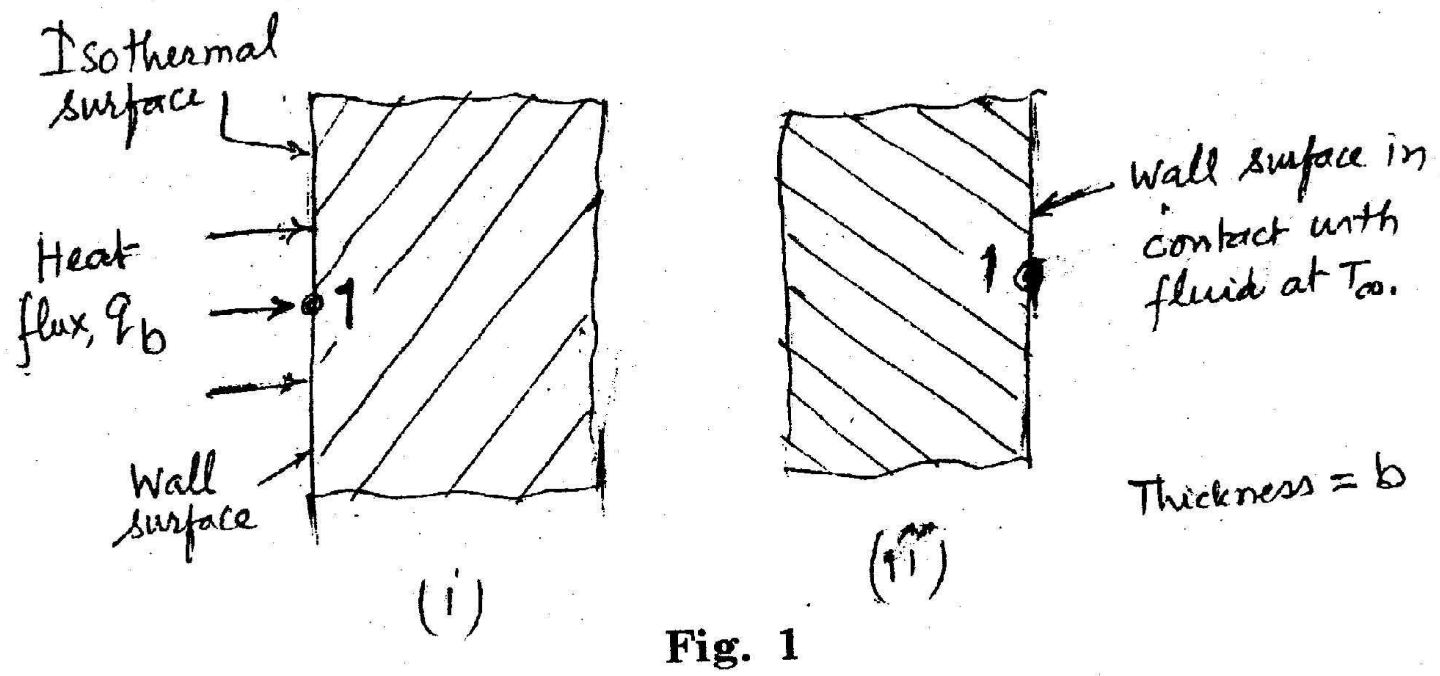

Fig. 1

4

OR

2 (a) Discuss development of hydrodynamic boundary layer

(i) Over a flat plate placed parallel to a fluid flowing at velocity U_∞

(ii) For laminar flow through a tube

(iii) for turbulent flow through a tube

Discuss variation of heat transfer coefficent for the above cases in the flow direction. 3+3

(b) Air at 300 K flows at a velocity of 10 m/s past a flat plate 3m long and 1m wide. The plate surface can be assumed at a uniform temperature of 400 K. Determine heat transferred from one side of the plate. The thermo-physical properties of air can be taken from the following table :

T (K)	ρ (kg/m^3)	c_p (kJ/kg K)	μ (kg/ms)	ν (m^2/s)	k W/mk	P_r
300	1.1774	1.0057	1.85×10^{-5}	15.7×10^{-6}	0.0262	0.708
350	0.998	1.009	2.08×10^{-5}	20.8×10^{-6}	0.030	0.697
400	0.8826	1.014	2.3×10^{-5}	25.9×10^{-6}	0.0336	0.689

10

UNIT - III

3 (a) Show by dimensional analysis that the functional relation in natural convection heat transfer can be presented as $Nu = C (G_r)^a (P_r)^b$

12

(b) Define and explain the physical significance of the following non-dimensional numbers

(i) Gr

(ii) Pr

(iii) Nu

(iv) Re

4

OR

3 (i) Discuss nucleate and film boiling, and CHF.

(ii) Discuss process of forced flow boiling in a vertical once through tube subjected to uniform heat flux q.

(iii) Develop Nusselt's equation of heat transfer for condensation of vapour over a vertical flat plate.

2+4+10

UNIT - IV

4 (a) Define overall heat transfer coefficient for a double pipe heat exchanger and derive its equation considering fouling factors.

4

(b) Develop equation of LMTD for a parallel flow heat exchanger. Clearly state the simplifying assumptions made in the development of above equation and how they affect the estimate of LMTD.

10+2

OR

4 Find the length of a counter-flow double pipe exchanger to cool 1000 kg/hr of hot water from 60°C to 30°C using cold water at 20°C and at a flow rate of 1500 kg/hr. Hot water flows through the tube of 18 mm ID and 22 mm OD, while the cold water flows through the annulas. The tube is placed in a 30 mm ID pipe. Neglect tube wall and scale resistances.

The thermo-physical properties of water can be taken from the following table :

t (^oC)	ρ (kg/m^3)	c_p (kJ/kgK)	k (W/mk)	v (m^2/s)	P_r
30	995.7	4.174	67.2×10^{-2}	0.81×10^{-6}	5.42
40	992.2	4.176	63.3×10^{-2}	0.66×10^{-6}	4.31
50	988.1	4.178	64.7×10^{-2}	0.56×10^{-6}	3.54

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UNIT - V

5 (a) State the Lambert's law. Prove that for a diffuse black surface, the intensity of normal radiation is $\left(\frac{1}{\pi}\right)$ times of the total emissive power of the body.

2+8

(b) The surface of the sun has an effective blackbody temperature of 5800 K. What fraction of the radiant energy of the sun lies in the range $0.01 \le \lambda \le 0.4 \mu m$, $0.4 < \lambda \le 0.8 \mu m$, and $0.8 \le \lambda \le .3 \mu m$? At what wavelength and frequency is the maximum energy emitted ? Tabulated values of radiation fraction may be used

λT $(\mu m - k)$	$F_{0-\lambda T}$
500	0.13×10^{-7}
1000	0.32×10^{-3}
1500	0.01285
2000	0.06672
2500	0.1617
3000	0.27322
3500	0.3826
4000	0.48085
4500	0.5640
5000	0.63371

λT $(\mu m - k)$	$F_{0-\lambda T}$
6000	0.7378
7000	0.8081
8000	0.8562
10000	0.9141
12000	0.9450
14000	0.96284
16000	0.9737
18000	0.9808
20000	0.98554
30000	0.9953

4+2

OR

5 (a) For the perpendicular plane surfaces (1 and 2) shown in **Fig. 2**, calculate the heat transfer between the surfaces. Neglect radiation or reflection from the surrounding surfaces. **Fig. 3** may be used to calculate the configuration or shape factor.

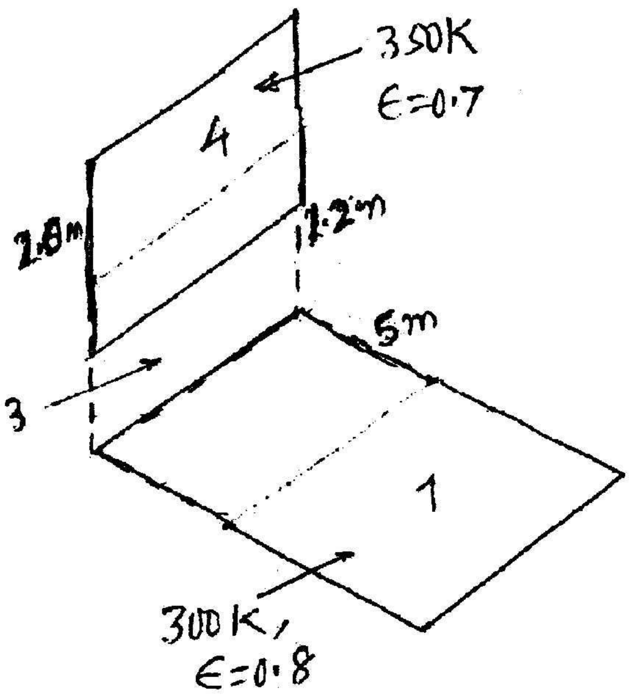

Fig. 2

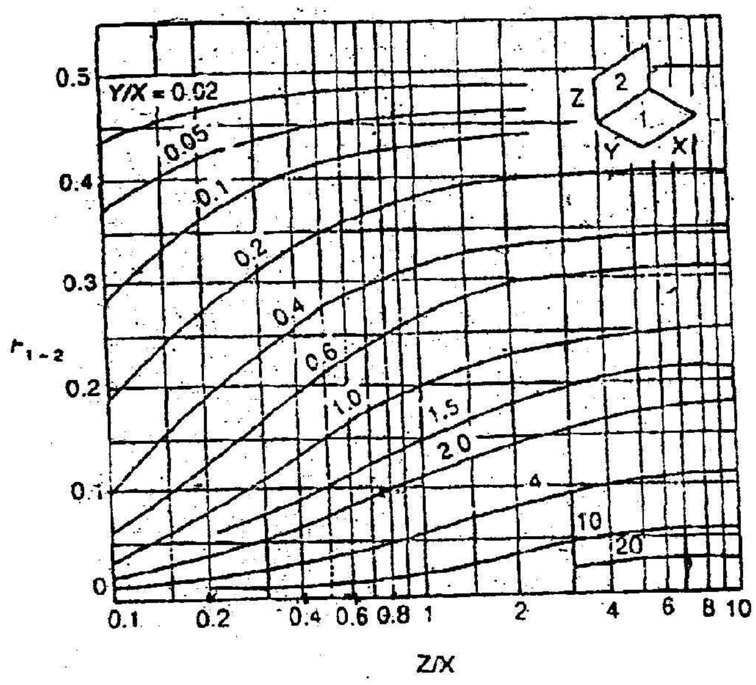

Fig. 3

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(b) Using the method of electric network for solving radiation problems,write nodal equations for a system consisting of four diffuse gray surfaces which see each other and nothing else.

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