

5E3176-Q

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Total Printed Pages : **7****5E3176-Q****B. Tech. (Sem. V) (Main) Examination, December - 2011**
Mechanical Engg.
5ME2 Heat TransferTime : **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)

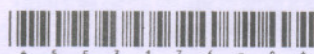
1. NIL 2. NIL**UNIT - I**

- 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?

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[Contd...

(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/m² °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 m² 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/m² °C and 20 W/m² °C, respectively.

8

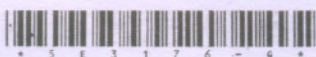
UNIT - II

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.

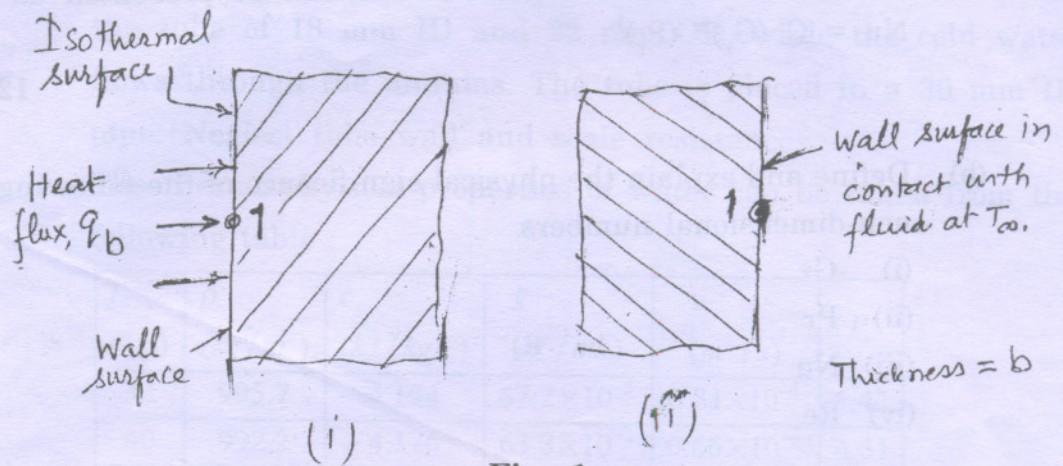


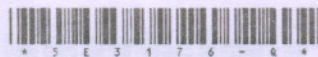
Fig. 1

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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 coefficient 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



UNIT - III

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

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- (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

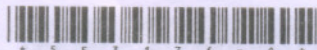
- 4 (a) Define overall heat transfer coefficient for a double pipe heat exchanger and derive its equation considering fouling factors.

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 annulus. 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 (°C)	ρ (kg/m ³)	c_p (kJ/kgK)	k (W/mk)	ν (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

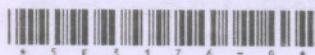
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UNIT - V

- 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 $0.01 \leq \lambda \leq 0.4 \mu\text{m}$, $0.4 < \lambda \leq 0.8 \mu\text{m}$, and $0.8 \leq \lambda \leq 3 \mu\text{m}$? 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.

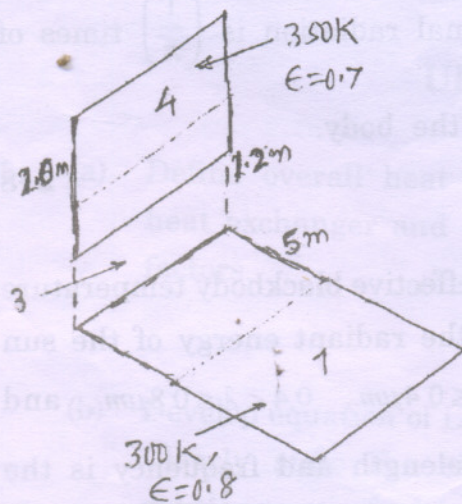


Fig. 2

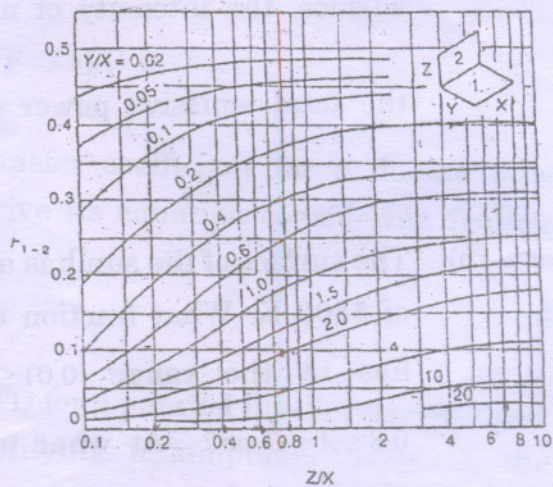


Fig. 3

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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.

8

Maximum Marks - 30
[Min. Passing Marks - 24]

Instructions to Candidates:

1. This paper contains questions on one question from each part. All questions carry equal marks. Candidates should first read the whole paper carefully and then select the questions to be attempted. Candidates should attempt questions in the order in which they are set.

2. Candidates are permitted to use a calculator. However, the use of a calculator is optional. Candidates are advised to use a calculator only if they are confident of their ability to use it.

UNIT - I

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

- Constant thermal conductivity
 - no heat generation
 - Steady state condition and
 - Steady state conduction with no heat generation
- Define and discuss thermal conductivity.

(b) What do you mean by composite insulation?

