Code: 13A03506

R13

B.Tech III Year I Semester (R13) Regular & Supplementary Examinations November/December 2016

HEAT TRANSFER

(Mechanical Engineering)

Use of heat transfer data book and steam tables are permitted in the examination hall

Time: 3 hours | Max. Marks: 70

PART – A

(Compulsory Question)

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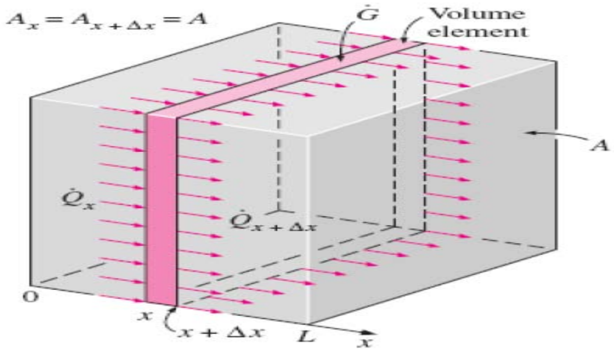
1 Answer the following: (10 X 02 = 20 Marks)

(a) Formulate a generalized equation (only the main equation) to express the energy balance on the ultra-thin volume element (see figure herewith) during a small time interval. Assume standard notations for density and specific heat.



(b) With proper diagrams, explain the various modes of heat transfer.

(c) What is the significance of Biot number? State and define its physical interpretation.

(d) State the condition which must be satisfied to treat the temperature distribution in a fin as one-dimensional.

(e) With the help of appropriate examples, explain how natural convection is different from forced convection?

(f) With reference to free convection, write short notes on Grashof Number.

(g) Briefly explain Nusselt's theory of condensation.

(h) Write your response to the statement, "In a heat exchanger, it is impossible for the exit temperature of the cold fluid to be greater than the exit temperature of the hot fluid when both fluids are single phase fluids".

(i) If a surface emits 200 W at a temperature of T, how much energy will it emit at a temperature of 2T?

(j) Explain how 'black surface', 'gray surface' and 'diffuse surface' differs.

PART – B

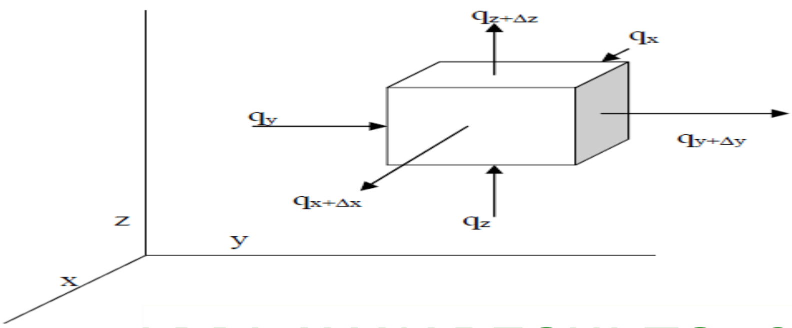
(Answer all five units, 5 X 10 = 50 Marks)

UNIT – I

2 The wall of a house (7 m wide and 6 m high) is made from 0.3 m thick brick with k = 0.6 W/mK. The surface temperature on the inside of the wall is 16^0C and that on the outside is 6^0C. Find the heat flux through the wall and the total heat loss through it.

OR

3 With reference to the figure given herewith, derive the most generalized form of steady state heat conduction equation.



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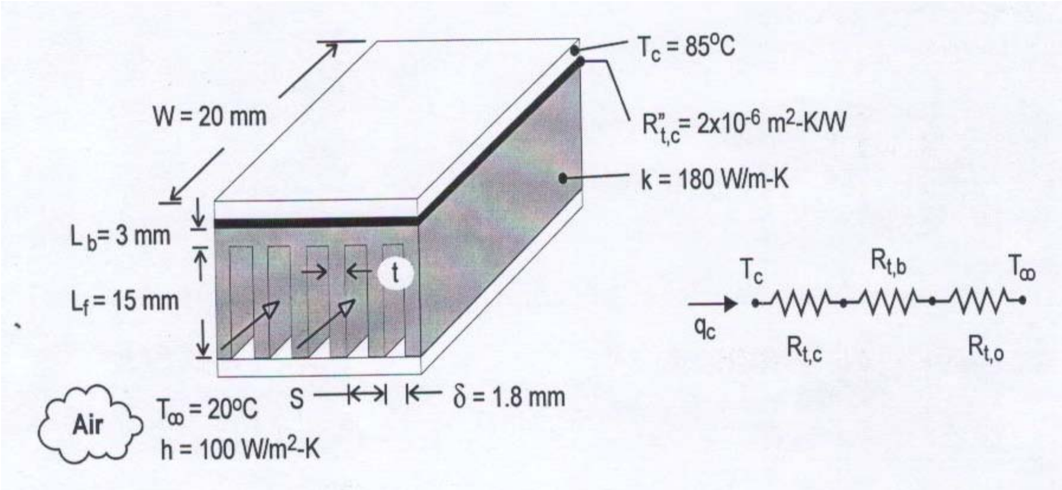
UNIT – II

4 A person is found dead at 5:00 pm in a room (Room temperature is 20^0C). At the aforesaid time, the temperature of the body is measured as 25^0C and the heat transfer coefficient is estimated to be h = 8 W/m^2.^{0}C. Modelling the body as a 30 cm diameter x 1.70 m long cylinder, prepare a detailed analysis and estimate the time of death of that person. Take the properties of the body as k = 0.617 W/m.^{0}C and initial body temperature = 37^0C. (Assume density = 996 kg/m^3 and C_p = 4178 J/kg.^{0}C)

OR

5 With the aid of the schematic representation and the assumptions given below, determine maximum allowable power for a 20 mm x 20 mm electronic chip whose temperature is not to exceed when the chip is attached to an air-cooled heat sink with N = 11 fins of prescribed dimensions.



Assumptions: (i) Steady-state. (ii) One-dimensional heat transfer. (iii) Isothermal chip. (iv) Negligible heat transfer from top surface of chip. (v) Negligible temperature rise for air flow. (vi) Uniform convection coefficient associated with air flow through channels and over outer surface of heat sink. (vii) Negligible radiation.

UNIT – III

6 The decorative plastic film on a copper sphere of 10 mm diameter is cured in an oven at 75°C. Upon removal from the oven, the sphere is subjected to an air stream at 1 atm and 23°C having a velocity of 10 m/s. Estimate how long it will take to cool the sphere to 35°C.
Assumptions: (i) Negligible thermal resistance and capacitance for the plastic layer. (ii) Spatially isothermal sphere. (iii) Negligible Radiation. Any other assumptions made should be correctly stated.

OR

7 State the significance of Buckingham's π – Theorem. With a suitable example, explain its application in convective heat transfer.

UNIT – IV

8 A heat exchanger consists of numerous rectangular channels, each 18 mm wide and 2.25 mm high. In an adjacent pair of channels, there are two streams: water k = 0.625 W/m.K and air k = 0.0371 W/m.K, separated by a 18 mm wide and 0.5 mm thick stainless steel plate of k = 16 W/m.K. The fouling resistance for air and water are 2 x 10^{-4} m^2 KW and 5 x 10^{-4} m^2 KW respectively. The Nusselt number (Nu_{Dh}) is 5.95, where the subscript 'Dh' refers to the hydraulic diameter. (i) Calculate the overall heat transfer coefficient ignoring both the thermal resistance of the separating walls and the two fouling resistances. (ii) Calculate the overall heat transfer coefficient with these resistances. (iii) Which is the controlling heat transfer coefficient?

OR

9 With proper illustration, explain how NTU method is advantageous than LMTD method.

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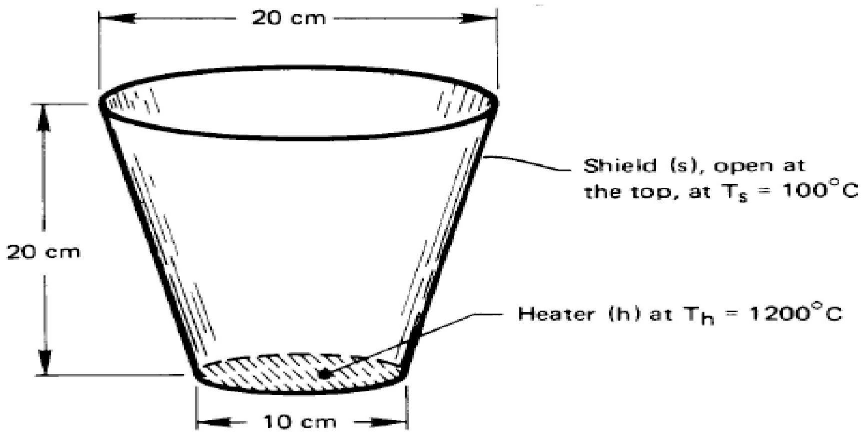
UNIT – V

10 (a) Write short notes on: (i) Stefan-Boltzmann's law. (ii) Plank's law.

(b) A system in space which generates a lot of waste heat has to be get rid of by radiation into deep, cold space. The power required to dump is 1.0 x 10^3 W. The external radiator has a surface area of 1.0 m x 2.0 m, useful emission from only one side and emissivity of 0.99 (good absorber). What is the equilibrium temperature of the radiator in degree Celsius?

OR

11 A heater (h) as shown in the figure below radiates to the partially conical shield (s) that surrounds it. If the heater and the shield are black, calculate the net heat transfer from the heater to the shield.



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