	Roll No.
Paper Code: ME 504	

B.TECH
(SEM V) ODD SEMESTER EXAMINATION 2016-17
HEAT AND MASS TRANSFER

[Time: 3 Hours] **[Max. Marks: 100]**

Note: (i) Attempt all questions.
(ii) Assume missing data suitably, if any.
(iii) Use appropriate equation / correlation and property data provided.
(iv) Use of Heisler's Charts is permitted.

Q.1. *Attempt any **TWO** parts of the following*:- **(10x2=20)**

(a) (i) Ahot water pipe with outside radius r_1 has a temperature T_1. A thick insulation applied to reduce the heat loss has an outer radius r_2 and temperature T_2. On T-r coordinates, sketch the temperature distribution in the insulation for one-dimensional, steady state heat transfer with constant properties. Give brief explanation, justifying the shape of the curve shown.
(ii) Derive an expression for critical radius of insulation for cylinder and discuss its significance.

(b) A copper (k = 401 W/m. K) cable of 30 mm diameter has an electrical resistance of $5 \times 10^{-3}\Omega$/m and is used to carry an electrical current of 250 A. The cable is exposed to an ambient air at 20 ˚C, and the associated convection coefficient is 25 W/ m^2. K. What are the surface and centerline temperatures of the cable?

(c) A 10 mm diameter electric wire with a resistance per unit length of $2\times10^{-4}\Omega$ / m is coated with an insulation of thermal conductivity k=0.20W/m.K. The insulation is exposed to ambient air at 30 ºC for which heat transfer coefficient is10W/m^2.K. Calculate the value of highest current that may be passed through the wire so that the temperature in any part of insulation does not exceed 200 ºC.

Q.2. *Attempt any **TWO** parts of the following:* **(10x2=20)**

(a) The sphere which is 12.7 mm in diameter is at 66º C before it is inserted into an air stream having a temperature of 27ºC. A thermocouple on the outer surface of the sphere indicates 55ºC, 69 s after the sphere is inserted into an air stream. Assume, and then justify, that the sphere behaves as a space-wise isothermal object and calculate the heat transfer coefficient. For pure copper (at 333k) take: ρ=8933 kg/m^3, c_p=389 J//kg K, and k=398 W/m K.

(b) A plane wall with a thickness of 0.1 m initially at a uniform temperature of 250˚C is suddenly immersed in an oil bath at 30 ˚C. Assuming the convection heat transfer coefficient for the wall in the bath is 500 W/m^2.K. Assuming one-dimensional heat transfer, calculate the surface temperature of the wall 9 min after immersion. The properties of the wall are k=50 W/m.K, ρ=7835 kg/m^3, and c=465 J/kg K.

(c) What do you understand by the "Corrected Length of Fin", how it is beneficial?
Two long copper rods (k = 379 W/m. K) of diameter D = 10 mm are soldered together end to end, with solder having a melting point of 650 ºC. The rods are in air at 25 ºC with a convection coefficient of 10 W/m^2 .K. What is the minimum power input needed to effect the soldering?

Q.3. *Attempt any **TWO** parts of the following:* **(10x2=20)**

(a) A flat plate of width w = 1 m is maintained at a uniform surface temperature, T_s = 230°C, by using independently controlled, electrical strip heaters, each of which is 50 mm long. If atmospheric air at 25°C flows over the plate at a velocity of 60 m/s, at what heater is the electrical input a maximum? What is the value of this input? For Air (at T = 400 K, p = 0.6 atm): $\nu = 44.02\times10^{-6}$ m^2/s, k = 0.0338 W/m.K, Pr = 0.690

(b) Explain the phenomenon of free convection on a vertical surface and highlight the role of Grashof Number and Rayleigh number**.**

OR

Derive the momentum equation for free convection in-terms of volumetric thermal expansion coefficient.

(c) Answer the following:

(i) For laminar/turbulent flow over a flat plate the heat transfer coefficient decreases with the distance from leading edge. Whether the statement is true or false? Substantiate your reply.

(ii) Discuss the significance of various dimensionless numbers in forced convection.

Q.4. *Attempt any **TWO** parts of the following:-* **(10x2=20)**

(a) A long, thin-walled horizontal tube 100 mm in diameter is maintained at 120°C by the passage of steam through its interior. A radiation shield is installed around the tube, providing an air gap of 10 mm between the tube and the shield, and reaches a surface temperature of 35°C. The tube and the shield are diffuse, gray surfaces with emissivity of 0.8 and 0.1 respectively. What is the radiant heat transfer from the tube per unit length?

(b) A flat bottomed hole 6 mm in diameter is drilled to a depth of 24 mm in a diffuse, gray material having an emissivity of 0.8 and a uniform temperature of 1000 K. Determine the radiant power leaving the opening of the cavity (hole). The opening of the cavity may be approximated as a black body at 0 K.

(c) What do you understand by the following?

(i) Space Resistance
(ii) Colored Surface
(iii) Plank's Distribution Law

Q.5. *Attempt any **TWO** parts of the following:* **(10x2=20)**

(a) Define Heat Exchanger Effectiveness. Derive an expression for Effectiveness of counter flow heat exchanger in terms of NTU.

(b) Derive an expression for molar diffusion rate for steady state equimolar counter diffusion.

OR

Discuss various modes of Pool boiling with the help of Pool boiling curve.

(c) Water (cp =4188 J/kg) at 225 kg/h is to be heated from 35 °C to 95 °C by means of a concentric tube heat exchanger. Oil (cp =2095 J/kg) at 225 kg/h and 210 °C is to be used for heating the water. The overall heat transfer coefficient based on the outer surface of the inner tube is 550 W/m2 K. Determine the length of the exchanger, if the outer diameter of the inner tube is 10 cm.

Correlations:

1. For Turbulent flow over a flat plate:
   $Nu_x = 0.0296\, Re_x^{4/5}\, Pr1^{/3}$ (0.6 <Pr< 60)
2. For Mixed boundary layer flow over a flat plate:
   $Nu_L = (0.037\, Re_L^{4/5} - 871)\, Pr1^{/3}$ ($0.6 < Pr < 60;\ Re_{x,c} < Re_L < 10^8; Re_{x,c} = 5 \times 10^5$)
3. For Double pipe heat exchanger :
   ε = 1- exp. (- NTU) ; for Cr = 0
   ε = NTU/ (1+ NTU) ; for Cr = 1