Code No: 156BC

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JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
B. Tech III Year II Semester Examinations, February/March - 2022
HEAT TRANSFER
(Mechanical Engineering)

Time: 3 hours **Max. Marks: 75**

Answer any five questions
All questions carry equal marks

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1.a) Derive steady state general Heat conduction equation without heat generation in cylindrical systems.
b) Write down the equation for conduction of heat through a slab or Plane wall. [10+5]

2.a) List the assumptions made while analyzing the heat flow from a finned surface.
b) A 2cm thick steel slab heated to 525^0C is held in air stream having a mean temperature of 25^0C. Estimate the time interval when the slab temperature would not depart from the mean value of 25^0C by more than 0.5^0C at any point in the slab. The steel plate has the following thermos-physical properties: $\rho = 7950$ kg/m^3, $c_p = 455$ J/kg-^{0}C, $k = 46$ W/m-^{0}C.h (heat transfer coefficient on plate surface) $= 36$ W/m^2-^{0}C. [5+10]

3.a) What are repeating variables and how are they selected for dimensional analysis?
b) 3000 kg of water is heated per hour from 30^0C to 70^0C by pumping it through a certain heated section of a 25 mm diameter tube. If the surface of the heated section is maintained at 110^0C, estimate length of the heated section and the rate of heat transfer from the tube to water. [5+10]

4.a) Derive an expression for LMTD for a Parallel Flow Heat Exchangers.
b) A hot square plate of 75 cm × 75 cm at 120^0C is exposed to atmospheric air at 40^0C. Find the heat lost from both surfaces of the plate if it is kept in vertical position. [8+7]

5.a) Water is boiled at atmospheric pressure by a horizontal polished copper heating element of diameter D = 5 mm and emissivity $\epsilon = 0.05$ immersed in water. If the surface temperature of the heating wire is 350^0C, determine the rate of heat transfer from the wire to the water per unit length of the wire.
b) State and explain the Stefan-Boltzmann law of radiation heat transfer, giving the nomenclature involved in it. [8+7]

6.a) It is required to heat the oil to 300^0C for frying purpose. A long ladle is used in frying pan. The section of the ladle is 5 mm ×18 mm. The surrounding air is at 30^0C and the thermal conductivity of the ladle material is 205 W/mK. If the temperature at a distance of 380 mm from the oil should not exceed 40^0C, determine convective heat transfer coefficient.
b) Derive an expression for temperature distribution under steady state in one dimensional heat conduction for a plane wall. [8+7]

7. An electrically heated thin foil of length L= 25mm and width W = 8 mm is to be used as a wind speed meter. Wind with a temperature T_∞ and velocity U_∞ blows parallel to the longest side. The foil is internally heated by an electric heater dissipating Q (Watts) from both sides and is to be operated in air with $T_\infty = 20^0C$, $C_p = 1.005kJ/kg\ K$, $\nu = 1.522 \times 10\text{-}^5\ m^2/s$, $\rho = 1.19\ kg/m^3$ and Pr = 0.72. The surface temperature, T_s of the foil is to be measured at the trailing edge - but can be assumed to be constant. Estimate the wind speed when $T_s = 32^0C$ and Q = 0.5 W. [15]

8.a) How heat exchangers of classified.

b) A double-pipe (shell-and-tube) heat exchanger is constructed of a stainless steel (k = 15.1 W/m ^{0}C) inner tube of inner diameter D = 1.5 cm and outer diameter Do = 1.9 cm and an outer shell of inner diameter 3.2 cm. The convection heat transfer coefficient is given to be hi = 800 W/m^2 ^{0}C on the inner surface of the tube and h_0 = 1200 W/m^2 ^{0}C on the outer surface. For a fouling factor of R_ri = 0.0004 m^2 ^{0}C/ W on the tube side and R_ro = 0.0001 m^2 ^{0}C/ W on the shell side, determine:

i) The thermal resistance of the heat exchanger per unit length.

ii) The overall heat transfer coefficients, U; and U_o based on the inner and outer surface areas of the tube, respectively. [5+10]

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