Roll Number: ____________________ Group: ____________________

THAPAR INSTITUTE OF ENGINEERING AND TECHNOLOGY, PATIALA
Department of Mechanical Engineering

B.E. (Fourth Year): Semester-7th
(Mechanical and Mechanical Production Engineering)
Course Code: UME712, Course Name: Heat Transfer
Time 3:00 hours

Session: 2019-20 (I)

Instructors: SSM & KLR
M. M.: 100

Note: Attempt all the questions and its sub parts at the same place. Take suitable assumptions wherever necessary. The use of relevant charts is allowed, if any.

Q1. The cylindrical head of an engine is 1 m long and has an outside diameter of 50 mm. Under typical operating conditions, the outer surface of the head is at a temperature of 150 °C and is exposed to ambient air at 40 °C with a convective heat transfer coefficient of 22 W/m^{2}K. The head has been provided with 12 longitudinal straight fins which are 0.75 mm thick and protrude 2.5 cm from the cylinder surface. Work out the increase in the heat transfer rate due to addition of fins. Also determine the temperature at the centre of the fin. Assume that fins have insulated tips and the thermal conductivity of the cylinder head and fin material is 72 W/mK. **(15)**

Q2. A long cylindrical shaft of radius 7.5 cm comes out of an oven at 815 °C throughout and is cooled by quenching it in a large bath of 38 °C coolant. If the coefficient of heat transfer between surface and coolant is 175 W/m^2 K, calculate the time it takes for the shaft centre to reach 116 °C. Assume that the thermal conductivity and thermal diffusivity of the material are 17.5 W/mK and 5.138 X 10^{-6} m^2/s. What would be the surface temperature of the shaft when its centre temperature is 116 °C.? Also calculate the temperature gradient at the outside surface at the same instant of time. **(15)**

Q3. Air at 2 bar and 40 °C is heated as it flows through a 30 mm diameter tube at a velocity of 10 m/s. If the wall temperature is maintained at 100 °C all along the length of the tube, determine the heat transfer per unit length of the tube using an appropriate correlation. Also calculate the increase in bulk temperature over one meter length of the tube. The following properties of air can be used for calculations, specific heat, C_p = 1.009 kJ/kgK, thermal conductivity, k = 0.0297 W/mK, and dynamic viscosity, μ = 20.6X10^{-6} Ns/m^2, P_r =0.694 and R_{air} = 0.287 kJ/kg-K. **(15)**

Q4. A one shell, two tube pass heat exchanger having 3000 thin wall brass tubes of 20 mm diameter has been installed in a steam power plant with a heat load of 2.3X10^8 W. The steam

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condenses at 50 °C and the cooling water enters the tubes at 20 °C at the rate of 3000 kg/s. Calculate the overall heat transfer coefficient, tube length per pass and the rate of condensation of steam. Take the heat transfer coefficient for condensation on the outer surfaces of the tubes as 15500 W/m^2K and latent heat of steam as 2380 kJ/kg. Further presume the following properties of fluid specific heat, C_p = 4180 J/kgK, thermal conductivity, k = 0.613 W/mK, and dynamic viscosity, $\mu = 855X10^{-6}$ Ns/m^2, P_r = 5.83. **(15)**

Q5. In an open heart surgery hypothermic conditions, the patents' blood is cooled before the surgery and then rewarmed afterwards. The task is accomplished by a concentric tube counter flow heat exchanger of length 500 mm with a thin walled tube of 60 mm diameter. The blood enters the heat exchanger at 20 °C and 0.05 kg/s is warmed by water at 60 °C and 0.12 kg/s. Determine the temperature of the blood at the exit from the heat exchanger and the heat flow rate. Assume the following date: C_p of the blood = 3500 J/kg K and C_p for water = 4186 J/kg K and the overall heat transfer coefficient is 475 W/m^2K. **(15)**

Q6. Two parallel plates, 0.5 m X 1 m each are spaced 0.5 m apart. One plate is maintained at 1000 °C and the second plate is at 500 °C and their emissivities are 0.2 and 0.5, respectively. The plates are located in a large room walls of which are maintained at 27 °C. The surfaces of plates facing each other exchanges heat by radiation. Determine the rates of heat lost by each plate and the heat gain of the walls by radiation. Use radiation network for solution. Assume shape factor between parallel plates, $F_{12} = F_{21} = 0.285$ and $\sigma = 5.67X10^{-8}$ W/m^2K^4. **(15)**

Q7. The net radiation from the surface of two parallel plates maintained at temperatures T1 and T2 is to be reduced by 79 times. Calculate the number of screens to be placed between two surfaces to achieve this reduction in heat exchange, assume the emissivity of the screens as 0.05 and that of surfaces as 0.8, respectively. **(10)**

List of formulae (all symbols have their usual meaning)

Entry region, laminar, between parallel planes	$Nu = 7.54 + \frac{0.03\,(D_h/L)\,Re\,Pr}{1 + 0.016[(D_h/L)\,Re\,Pr]^{2/3}}$
Entry region, laminar, circular conduit	$Nu = 3.66 + \frac{0.065\,(D/L)\,Re\,Pr}{1 + 0.04[(D/L)\,Re\,Pr]^{2/3}}$
Laminar, constant surface temperature, circular conduit	$Nu = \frac{hD}{k} = 3.66$
Turbulent, fully developed, circular tube	$Nu = 0.023\,Re^{0.8}\,Pr^{n}$ n = 0.4 for heating and 0.3 for cooling

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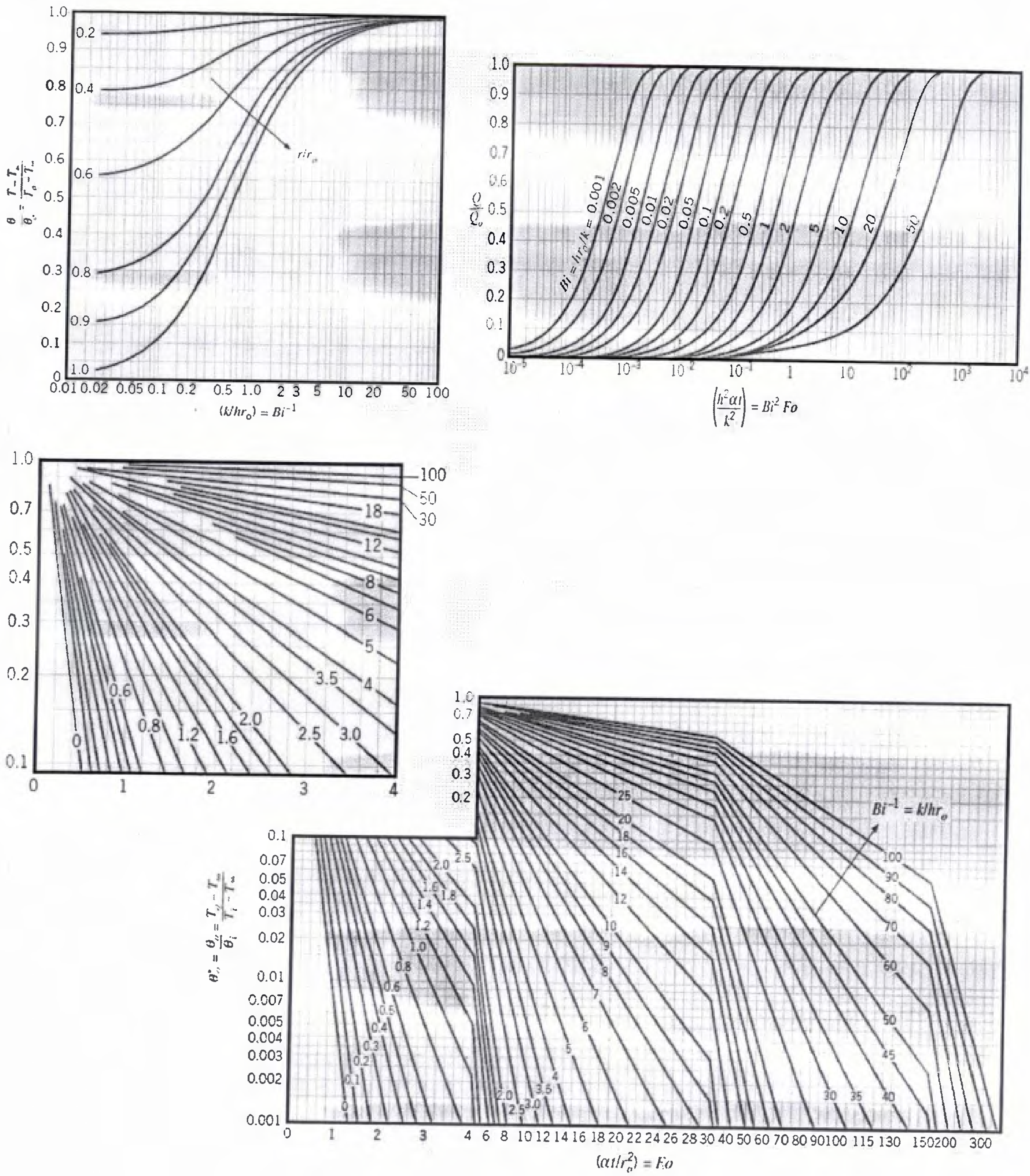

Figure 1. Heisler and Grover Charts for Cylinder