Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY

A Constituent Institute of Manipal University, Manipal

VI SEMESTER B.TECH (MECHANICAL ENGINEERING)
END SEMESTER EXAMINATION APRIL/MAY 2017
SUBJECT: HEAT TRANSFER (MME 3201)
REVISED CREDIT SYSTEM

Time: 3 Hours **Max. Marks: 50**

Note: (i) Answer all the questions
(ii) Missing data, if any, may be appropriately assumed
(iii) Draw the sketch as applicable
(iv) Assumptions made must be clearly mentioned

1A Derive an expression for steady state heat transfer through a composite sphere. 04

1B In a fire tube boiler, hot gas flows inside steel tubes of 50 mm inner diameter and 60 mm outer diameter at a temperature of 600 ^oC. The tubes are covered with saturated water at 40 bar and 250 ^oC which evaporates into steam. If the steam production rate is to be 1000 kg/hr and the latent heat of vaporization = 1712 kJ /kg corresponding to boiler conditions, what should be the total length of the tube? k_{steel} = 55 W/m ^oC. Fire side heat transfer coefficient, h_g = 20 $W/m^{2o}C$. Water side heat transfer coefficient h_w = 500 $W/m^{2o}C$. 04

1C Explain applicability of lumped system analysis and explain the significance of Biot number. 02

2A Derive an expression for temperature distribution in a cylindrical rod in which one-dimensional radial conduction is taking place under steady state conditions with uniform heat generation $\dot{q}$. 05

2B The handle of a ladle used for pouring molten metal at 520 ^oC is 420 mm long, and is made of 22 x 16 mm steel bar. It is proposed to make a hollow steel handle of 1.2 mm thick to the same rectangular shape to reduce the grip temperature. Surface heat transfer coefficient, h = 10 W/m^{2}K. Air (ambient) temperature Ta = 30 ^oC, k_{steel} = 40 W/mK. Neglect heat transfer from the inner surface of the hollow shape. Find the reduction in grip temperature. 05

3A Water is heated while flowing through a *1.5 cm X 4 cm* rectangular duct at a velocity of *1.5m/s*. Entry temperature of water is *30 ^oC*. The wall of the duct is maintained at *80 ^oC*. Determine the length of the duct required to raise the temperature of water by *30 ^oC*. Take the correlation
$Nu = 0.023Re^{0.8}Pr^{0.33}$ Take property of water at mean temperature as follows.
$\rho = 985.5 kg/m^3, \nu = 0.57\times10^{-6} m^2/s, k = 0.683 W/m^oC$, Cp = 4.18kJ/kgK 04

3B Explain with suitable sketches and graphs, the boiling regimes, boiling curve, film-wise condensation and drop-wise condensation 04

3C Copper bus bar of diameter 15 mm and 1m length is cooled with cross flow of dry air. The air velocity is 1 m/s and its temperature is 20 ^{o}C. Calculate the heat transfer

Coefficient from the copper bus bar to the cooling air and admissible current intensity for the bus bar on the condition that its temperature should not exceed 80 ^{o}C. Take electrical resistivity of copper as 0.0175 ohm. mm^2/m. Use the formulae for finding the heat transfer coefficient

At T_f = 50 ^{o}C, $k = 0.0259 W/m^oC$, $\nu = 15.06 \times 10^{-6} m^2/s$

$Nu_f = 0.44\left(\mathrm{Re}_f\right)^{0.5}$ *when* $10 < \mathrm{Re}_f < 1 \times 10^3$

$Nu_f = 0.22\left(\mathrm{Re}_f\right)^{0.6}$ *when* $10^3 < \mathrm{Re}_f < 2 \times 10^5$ 02

4A Derive an expression for calculating the effectiveness of a parallel flow heat exchanger in terms of overall heat transfer coefficient, area of heat exchanger and the heat capacity. 05

4B A counter-flow heat exchanger is employed to cool 0.55 kg/s (c_p = 2.45 kJ/kg°C) of oil from 115°C to 40°C by the use of water. The inlet and outlet temperatures of cooling water are 15°C and 75°C, respectively. The overall heat transfer coefficient is expected to be 1450 W/m^2°C. Calculate the mass flow rate of water and the surface area required. Also calculate the effectiveness of heat exchanger using NTU method. Take Cp of water = 4.18kJ/kgK. 05

5A Derive an expression for radiation heat exchange between two concentric cylindrical gray bodies by using electrical analogy. 05

5B Calculate the rate of heat transfer by radiation per unit area between two parallel steel plates, one at 300^oC and the other at 30^oC. The distance between them is small compared to their areas. If a thin polished copper plate is introduced as a radiation shield between the two surfaces, determine the percentage reduction in heat transfer. Take emissivity of steel plates = 0.8, emissivity of copper plate = 0.05. 05