Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY

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VI SEMESTER B. TECH (MECHANICAL ENGINEERING)

END SEMESTER EXAMINATIONS, APRIL 2019

SUBJECT: HEAT TRANSFER [MME 3201]

REVISED CREDIT SYSTEM

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data if any, may be suitably assumed.

1A. Derive an expression for critical thickness of insulation for an electric wire carrying current. Explain the meaning of critical thickness of insulation. **05**

1B An electric hot plate is maintained at a temperature of 350 °C, and is used to keep a solution boiling at 95 °C. The solution is contained in a cast-iron vessel of wall thickness 25 mm, which is enamelled inside to a thickness of 0.8 mm. The heat transfer coefficient for the boiling is 5.5 kW/m^{2}K, and the thermal conductivities of the cast iron and enamel are 50 W/mK and 1.05 W/mK, respectively. Calculate the overall heat transfer coefficient and the rate of heat transfer per unit area. **05**

2A A current of 300 amperes passes through a stainless steel wire of 3 mm diameter and k = 20 W/m°C. The resistivity of the wire is 70 x 10^{-8} Ωm and the length of the wire is 3m. If the wire is submerged in a fluid maintained at 40 °C and convective heat transfer coefficient at the wire surface is 2000 W/m^2°C, calculate the steady state temperature at the center and at the surface of wire. **05**

2B Derive an expression for the rate of heat transfer across a fin of uniform cross section and maintained between two hot sources of temperature T_1 and T_2 with convective boundary condition applied on the fin surface. **05**

3A Using Buckingham's pi theorem, derive the dimensionless parameters such as Reynolds numbers, Prandtl number and Nusselt number for a forced convection system. **04**

3B A 10 cm x 10 cm x 10 cm block is suspended in still air at 10 ^{o}C. All the surfaces are maintained at 150 ^{o}C. Determine the total heat transfer from the block. Use the following correlations. **03**

$Nu = 0.59(Ra)^{1/4}$ For vertical surface

$Nu = 0.54(Ra)^{1/4}$ For top surface

$Nu = 0.27(Ra)^{1/4}$ For bottom surface

$\nu = 2.107\times10^{-5}\ \mathrm{m^2/s},\ k = 0.03\ \mathrm{W/m^oC},\ \rho = 1\ \mathrm{kg/m^3}$

3C A vertical plate 0.6 m high and maintained at 40 °C is exposed to saturated steam at atmospheric pressure. Calculate the following:

(i) The rate of heat transfer, and

(ii) The condensate rate per hour per meter of the plate width for film condensation.

The properties of water film at the mean temperature are:

$\rho = 980.3$ kg/m^3, $k = 66.4 \times 10^{-2}$ W/m°C, $\mu = 434 \times 10^{-6}$ Ns/m^2 and h_{fg} =2257 kJ/kg. **03**

Assume vapor density is small compared to that of the condensate.

Take $$h = 0.943\left[\frac{\rho(\rho - \rho_v)k^3 g\, h_{fg}}{\mu L(T_{sat} - T_s)}\right]^{0.25}$$

4A Oil is to be cooled to 100 ºC in a concurrent heat exchanger by transferring its heat to cooling water that leaves the exchanger at 30 ºC. However, it is now required that the oil must be cooled down to 75 ºC by increasing the length of heat exchanger, while oil and water flow rates, their inlet temperature and other dimensions of the exchanger keeping constant. The inlet temperature of water and oil being 15 ºC and 150 ºC respectively. If the original cooler was 1 m long, calculate the outlet temperature of water in new cooler and the length of new cooler. **05**

4B Derive an expression for effectiveness of a parallel flow heat exchanger using NTU method. **05**

5A Explain the term Radiosity. Using electrical analogy, derive an expression for radiation heat exchange between two concentric cylinders. Show the circuit diagram for space and surface resistances. **05**

5B A cryogenic fluid flows through a long tube of 20 mm diameter, the outer surface of which is diffuse and gray (ϵ_1=0.02) at 77 K. This tube is concentric with a larger tube of 50 mm diameter, the inner surface of which is diffuse and gray (ϵ_2=0.05) and at 300 K. The space between the surfaces is evacuated. Calculate the heat gain by cryogenic fluid per unit length of tube. If a thin radiation shield of 35 mm diameter (ϵ_3=0.02) both sides is inserted midway between the inner and outer surfaces, calculate the percentage change in heat gain per unit length of the tube. **05**

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