Assignment – I
MED 3101 - Heat and Mass Transfer

1. A composite wall consists of 20 mm thick steel plate backed by insulation brick ($k = 0.39$ W/m K) of 50 cm thickness and overlaid by mineral wool of 20 cm thickness ($k = 0.05$ W/m K) and 70 cm layer of brick of ($k = 0.39$ W/m K). The inside is exposed to convection at 650°C with $h = 65$ W/m^2 K. The outside is exposed to air at 35°C with $h = 15$ W/m^2K. Determine the heat loss per unit area and interface temperatures.

2. A spherical vessel containing hot fluid at 160°C (in a chemical process) is of 0.4 m OD and is made of Titanium of 25 mm thickness. The thermal conductivity is 20 W/m K. The vessel is insulated with two layers of 5 cm thick insulations of thermal conductivities 0.06 and 0.12 W/m K. The outside is exposed to surrounding at 30°C with a convection coefficient of 15 W/m^2 K. Determine the rate of heat loss, the interface temperatures.

3. An electric wire of 3 mm of having surface temperature 85°C is covered with an insulation of 0.1 W/m K conductivity. Find the thickness of insulation that will give maximum rate of heat dissipation for a film coefficient of 20 W/m^2 K. Also determine the rate of heat dissipation per unit length and outside surface temperature of the insulation. The ambient temperature is 27°C.

4. Determine the heat transfer rate from the rectangular fin of length 20 cm, width 40 cm and thickness 2 cm. The fin has a thermal conductivity of 150 W/m K. The base temperature is 100°C and the fluid is at 20°C. The heat transfer coefficient between the fin and the fluid is 30 W/m^2 K.

5. A thermocouple in the form of a long cylinder of 2 mm diameter initially at 30ºC is used to measure the temperature of a cold gas at –160ºC. The convection coefficient over the surface is 60 W/m2K. The material properties are: density = 8922 kg/m^3, specific heat = 410 J/kg K, conductivity = 22.7 W/m K. Determine the time it will take to indicate –150ºC.

Assignment – II
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1. Air at atmospheric pressure and at 40°C flows with a velocity of 0.9 m/s along the flat plate. The temperature of plate is maintained at 90°C. Determine the velocity boundary layer thickness and the local friction coefficient at a distance of 0.61 m from the leading edge of the plate.

2. Air at a temperature of 27°C is moving at a velocity of 0.3 m/s past a 40 W incandescent bulb. The bulb may be treated as a sphere of 50 mm diameter with its surface temperature of 127°C. Calculate the heat transfer coefficient and power lost due to convection.

3. Water in a tank is heated by a horizontal steam pipe of 0.25 m diameter maintained at 60°C. The water is at 20°C. Calculate the value of convective heat transfer coefficient and heat transfer rate.

4. Determine the area required in parallel flow heat exchanger to cool oil from 60°C to 30°C using water available at 20°C. The outlet temperature of the water is 26°C. The rate of flow of oil is 10 kg/s. The specific heat of the oil is 2200 J/kg K. The overall heat transfer coefficient U = 300 W/m^2 K. Compare the area required for a counter flow exchanger.

5. A heat exchanger of total outside surface area of 17.5 m^2 is to be used for cooling oil at 200°C with a mass flow rate of 2.77 kg/s having a specific heat of 1.9 kJ/kg K. Water at a flow rate of 0.83 kg/s is available at 20°C as a cooling agent. Calculate the exit temperature of the oil if the heat exchanger is operated in a (i) parallel flow (ii) counter flow modes. Take U = 300 W/m^2 K