Birla Institute of Technology and Science, Pilani

II Semester, 2022-23

Dated: 13/03/2023 Open Book

ME F220 Heat Transfer

Time: 120 Minutes Mid semester examinations

Marks : 50 Marks weightage: 25%

(Only hand written class notes, text book and Data Handbook will be allowed)

Part A (Answer in one or two sentences only. Suggested time 30 minutes). **[10x2=20M]**

Q1) Compare the critical radius of identical wire used in domestic wiring and water proof motor used in submersible pump.

Q2) Two insulations materials A&B of identical thickness are to be used as layers in a composite cylinder to reduce the heat loss. If Ka>Kb, Which of the two material should form the first layer on the hot cylinder to effectively reduce the heat loss. Justify your answer.

Q3) An infinite slab of thickness 2L having **Bi>0.2** has $\theta_O/\ \theta_i = 0.3$ after quenching in a convective environment for time "t" seconds. What will be the dimensionless temperature ratio of center of the cube having side as 2L for the same time of quenching assuming all other conditions identical?

Q4) Flat ice block at 0^OC is exposed to stream of hot air at 40^OC flowing over the surface and parallel to it. Which part of the ice will melt first? Justify your answer.

Q5) What will be the relations between center node and surrounding nodes for the situation given in the figure given below under steady state 2D conduction?

Q6) Some students of your class did the experiment on wind tunnel to study the development of hydrodynamic boundary layer (BL) for laminar flow over a flat plate in the month of January and some other students will do the same experiment in the month of April. If the free stream velocity if same, compare the shape of the BL obtained by these two batches of students in a single figure. Justify your answer.

Q7) Why the scoop used for cone ice cream is preferably in spherical shape?

Q8) Explain the situation in which fin reduces heat transfer rather than augmenting it with specific example and justification. (Need to prove Fin effectiveness is <1)

Q9) Why the metallic glasses have thickness in few microns only? Justify your answer from heat transfer perspective.

Q10) A heater having constant heat flux outside and perfectly insulated outside the heating coil is used to heat water flowing through the tube. Someone wish to use it for heating the air for spatial heating during winter by attaching a blower. Would you appreciate his creativity? Justify your answer.

Part B (Suggested time 60 minutes) **[3x10-30M]**

Q11) A 20cm long and 5mm diameter copper rod (K=330W/mK) is uniformly generating heat at a rate of $1MW/m^3$ only for the first 10 cm length . This part of the rod is perfectly insulated on all the sides. Remaining 10cm length of the rod is exposed to convective environment having heat transfer coefficient of $25W/m^2K$ and exposed to atmosphere at 25^OC. Neglecting the heat loss from the two ends of the rod, find out the heat loss from the rod and the temperature distribution along the entire length of the rod. Assume 1D steady state conduction.

Q12) Oranges are assumed to be of spherical shape having 6cm diameter. They are initially at 28^OC. (K=0.45W/mK and $\alpha = 1.3x10^{-7}m^2/s$). Center of the orange is to be cooled to 4^OC for long term preservation. It is done by passing cooled air at -4^OC over it at a velocity of 0.3m/s leading to heat transfer coefficient of $30W/m^2K$. Find the time required for the center of the orange to attain the required preservation temperature. Also find whether any part of the orange will freeze during the process of cooling within this time. If so find the radius up to which the orange will not freeze.(Freezing occurs at 0^OC).

Q13) Parabolic concentrating collector tubes made of copper used for solar thermal applications can withstand maximum temperature of 475^OC only. At a given location the solar heat flux during the peak summer can be $1200W/m^2$. Concentration ratio of the collector is 20. Concentration ratio is defined as the heat flux at the absorber tube to the flat surface. Find the minimum velocity of the heat transfer fluid (HTF) required to ensure the temperature of the copper tube does not increase beyond the tolerable limit if the maximum exit temperature of the fluid is 450^OC. Property values of Heat Transfer fluid are: Density $=700kg/m^3$, K=0.078W/mK, Cp=2.6kJ/kgK, Dynamic viscosity$=0.15x10^{-3}Ns/m^2$. Diameter of the tube is=5cm with negligible thickness.
