# Birla Institute of Technology and Science, Pilani

**II Semester, 2022-23**

**Dated: 06/05/2023OpenBook**

**ME F220 Heat Transfer**

**Time: 180 Minutes Comprehensive Examinations**

**Marks :70 Marks weightage: 35%**

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

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**Part A** (Answer in one or two sentences only. Suggested time 45 minutes). **[ 10x2=20M]**

**Q1)** In the heat transfer lab, while doing the experiment on fins under natural convection, you might have observed that the experimental value of temperature distribution along the length of the fin is always lower than the theoretical temperature distribution obtained from the standard equation for convective boundary condition. Explain the possible reason(s) for this deviation.

**Q2)**Draw the temperature distribution in a new parallel flow heat exchanger and compare it with the deviation after long service with fouling in the heat transfer surfaces with proper justification.

**Q3)**Cooker manufacturing companiescome up with copper bottom pressure cookers at increased price and claim that such cookers will help in fuel saving and faster cooking. Do you agree with this? Justify your answer.

**Q4)** Find the shape factor for a blindcylindrical hole within itself taking Diameter=Height.

**Q5)**Bottom surface of a horizontal enclosed space of dimension 1mx1m and distance of separation of 1cm is maintained at $14^{O}$C and the top surface facing the bottom surface is maintained at $60^{O}$C. Find the total heat transfer between the surfaces by all modes. Take emissivty of inside surfaces facing each other as 0.1.

**Q6)**In a counter flow heat exchanger, U=500W/$m^2$K and A=10$m^2$. Hot fluid enters at $120^{O}$C and leaves at $80^{O}$C. Cold fluid enters at $20^{O}$C and leaves at $60^{O}$C. Find the heat exchange between the hot and cold fluids.

**Q7)**A long slender steel cylinder (D<<L) is to be quenched in a bath for heat treatment. Would you recommend quenching it vertical or horizontal to ensure more uniform structure (Cooling rate) along the length? Justify your answer.

**Q8)**In a turbulent flow through tubes under constant heat flux condition satisfying DB correlation, find the percentage change in the heat transfer coefficient if the velocity is doubled.

**Q9)** Array of vertical fins are used under natural convection. Can we use Total Q=NxQ/fin always? Justify your answer.

**Q10)** Usually fin equations are derived for convective fins. This is not valid in space as there is no possibility of convection. Write an energy balance equation for a pin fin losing heat purely by radiation in space taking a small elemental area along the length of the fin.

**Part B (Suggested time 135 minutes)** **[5x10=50M]**

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**Q11)** A 1mx1m plate (K=0.66W/mK) of 10cm thickness is kept horizontally and uniformly generate heat at a rate of 10kW/$m^3$. This plate is perfectly insulated at the bottom and side surfaces. It is cooled by air flowing at a temperature of 34$^O$C parallel to the top surface. Maximum temperature of the plate at any location is not to exceed 175$^O$C due to safety reasons. Find the minimum free stream velocity of the air required for safe operation. Assume the flow is fully turbulent from the leading edge.

**Q12)**Aluminum (K=237W/mK) pin fin of 5mm diameter and 5cm length is attached to a wall maintained at a constant temperature of 100$^O$C. Air at a temperature of 34$^O$C flows across the fin with a velocity of 20m/s. Taking the air property at an average film temperature of 340K, find the minimum temperature of the fin and its location. Neglect the heat loss from the tip. Also find the heat loss from the fin surface and fin effectiveness. What will be the effect of doubling the velocity of air on these parameters?

**Q13)** Outer surface of a horizontal tube having diameter of 5 cm is maintained constant at 100$^O$C and exposed to a room to be maintained at 14$^O$C during winter. If the rate of heat loss from the room is 100W/$m^2$ and the total surface area of the room is 500$m^2$, Find the total length of the tube required to maintain the room at the given temperature. Take the surface emissivity of the outer surface of the tube as 0.8. Neglect the temperature difference between the room air and interior surface of the wall. Also find the dominant mode of heat transfer from the tube surface.

**Q14)** One unit of Chiller plant at BITS Pilani has a capacity of 250TR operating at its full capacity cools the water from 11$^O$C to 9$^O$C.Water flows through the tube and the liquid refrigerant at -10$^O$C cools the water from the shell side. Refrigerant side heat transfer coefficient is 2000W/$m^2$K and the water flows through the copper tube of ID 35mm and thickness 3mm with a velocity of 1m/s. One shell pass and two tubes passes shell and tube heat exchanger is used. Find a) the total number of tubes required for the evaporator unit of the chiller plant.Also find b) the length required for each pass. c) In commercial complexes of metro cities, due to scarcity of space, it is essential to make a compact design of the evaporator. Suggest suitable method for reducing the size. (Take property values of water at 10$^O$C).

**Q15)** a) Why the water wall tubes of power plants fails in the mist flow regime? Explain with proper HTC variation in the flow boiling regimes.[2]

b) Explain the effect of surface roughness on the pool boiling curve.[2]

c) In the lab experiment on pool boiling, the wire of 2.5cm length and 0.5 mm diameter fuses when the values of voltage and current of 10V and 4A. Determine the peak heat flux. [2]

d) Explain the role of Phase Change Materials on energy storage.[2]

e) Why the phase change heat transfer plays an important role in compact designing of Klystron.[2]

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