

B. Tech III Year II Semester Examinations, April/May - 2012**HEAT TRANSFER****(Common to ME. AME)****Time: 3 hours****Max. Marks: 75****Answer any five questions****All questions carry equal marks**

1. a) Derive the expression for temperature distribution under one dimensional steady state heat conduction for a cylinder.
b) A 15cm outer diameter steam pipe is covered with 5cm of high temperature insulation ($k = 0.85 \text{ W/mk}$) and 4 cm of low temperature insulation ($k = 0.72 \text{ W/mk}$). The steam is at 500°C and ambient air is at 40°C . Neglecting thermal resistances of steam and air sides and metal wall, calculate the heat loss from 1000m length of the pipe. [15]
2. a) Explain why an insulated small diameter wire has a higher current carrying capacity than an uninsulated one.
b) A plane wall 80mm thick (thermal conductivity = 0.15 W/mk) is insulated on one side while the other side is exposed to environment at 90°C . The rate of heat generation within the wall is $12 \times 10^4 \text{ W/m}^3$. If the convective heat transfer coefficient between the wall and the environment is $560 \text{ W/m}^2\text{K}$, determine the maximum temperature to which the wall will be subjected. [15]
3. a) Consider a sphere and a cylinder of equal volume made of copper. Both the cylinder and sphere are initially at the same temperature, and are exposed to convection in the same environment. Which one do you think will cool faster, the cylinder or the sphere? Why?
b) A 3mm thick copper plate of $0.4 \times 0.4 \text{ m}^2$ area at 300°C is suddenly dipped into oil at 20°C . Calculate the time required for the plate to reach 40°C . Assume heat transfer coefficient = $90 \text{ W/m}^2\text{K}$, density = 800 kg/m^3 , thermal conductivity = 350 W/mK , Specific heat = 380 J/kg K . [15]
4. a) Explain the development of hydrodynamic and thermal boundary layers over a flat plate .
b) Ethylene glycol at 40°C flows over a flat plate with a velocity of 8 m/ sec. The plate is 3m long and maintained at 100°C . Calculate the local heat transfer coefficient at the end of the plate and average heat transfer coefficient over the entire length. Also find the rate of heat transfer from the plate per unit width. [15]
5. a) Explain the development of hydrodynamic and thermal boundary layers on a vertical plate in natural convection.
b) A vertical plate 20 cm x 60 cm size is at 110°C in an atmosphere at 30°C . Determine the rate of heat transfer by free convection from the plate when 20 cm side is kept vertical. [15]

6. a) Discuss the effect of non condensable gases on condensation.
- b) Saturated steam at 54°C condenses as a film on the outside surface of a 25mm OD, 3.66m long vertical tube. The tube surface is maintained at a temperature of 43°C . Calculate the average condensation heat transfer coefficient and the rate of steam condensation at the bottom of the tube. [15]
7. a) Sketch the temperature variations in parallel flow and counter flow heat exchangers.
- b) Oil with a specific heat of 2 KJ/ kg K is cooled from 110°C to 70°C by a flow of water flow in a counter flow heat exchanger. Water flows at the rate of 2 kg/sec and is heated from 35°C to 65°C . The overall heat transfer coefficient is estimated to be $0.37 \text{ KW/ m}^2\text{K}$. Determine the exit temperatures of oil and water, if the water flow rate drops to 1.5 kg / sec at the same oil flow rate. [15]
8. a) State and explain Kirchoff's identity. What are the conditions under which it is applicable?
- b) Two parallel grey planes with emissivities of 0.8 and 0.7 are maintained at 800°C and 1500°C . What is the net radiant energy exchange? What would be the reduction in heat transfer if a radiation shield of polished aluminum (Emissivity = 0.04) is placed between them? [15]

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1. a) Explain the respective rate equations governing conduction, convection and radiation.
- b) A copper rod of thermal conductivity 360 W/mK diameter 10 cm and length 40 cm acts as a stiffener between two plates maintained at 100°C and 80°C . Determine the heat flow through the rod assuming that the lateral surface of the rod is perfectly insulated. [15]
2. a) What is critical thickness of insulation on a small diameter wire or pipe? Explain its physical significance and derive an expression for the same.
- b) A wall of a house is constructed from a 11 cm layer of common brick (thermal conductivity = 0.7 W/mK) followed by a 4 cm layer of plaster (thermal conductivity = 0.48 W/mK). What thickness of loosely packed rock – wool insulation (thermal conductivity = 0.065 W/mK) should be added to reduce the heat loss through the wall by 75 percent? [15]
3. a) What are Fourier and Biot numbers? What is their physical significance?
- b) A steel cylinder of diameter 0.25 m and length 0.8 m initially at 25°C is placed in a furnace where the temperature is 1000°C . Determine the temperature at the centre and on the surface of the cylinder after a lapse of 1 hr . (Assume thermal conductivity = 35 W/mk , density = 7800 kg/m^3 , specific heat = 0.83 kJ/kg k , heat transfer coefficient = $233 \text{ W/m}^2\text{k}$). [15]
4. a) What is entrance length? How can it be found for laminar and turbulent flow conditions through a tube?
- b) In a straight tube of 50 mm diameter, water is flowing at a velocity of 15 m/sec . The tube surface temperature is maintained at 60°C and the flowing water is heated from the inlet temperature 15°C to an outlet temperature of 45°C . Calculate i) the heat transfer coefficient from the tube surface to water.
ii) the length of the tube . [15]
5. a) Explain about the location and magnitude of maximum velocity in the boundary layer formed on a i) heated ii) cooled vertical plate.
- b) An uninsulated duct of width 0.75 m and height 0.3 m is exposed to air at 15°C on its outer surface. If the surface temperature of the duct is maintained at 45°C , compute the loss of heat from the duct per meter length. [15]

6. a) How does radiation play an important role in boiling heat transfer?
b) A horizontal platinum wire of 1.27 mm diameter is used as a heating element for water at saturation temperature and atmospheric pressure. Estimate the mean heat transfer coefficient of the boiling regime with an excess temperature of 650°C . Assume emissivity of platinum as unity. [15]
7. a) Define heat exchanger effectiveness and explain its significance.
b) A heat exchanger has a total surface area of 15 m^2 . Hot oil enters at 110°C at a rate of 3 kg/sec having specific heat = 1.9 KJ/kg K . Water enters at 35°C as coolant at 2.3 kg /sec . If over all heat transfer coefficient = $320\text{ W/m}^2\text{K}$, find the outlet temperature of the oil and water for counter flow arrangement. [15]
8. a) Distinguish between a black body and grey body.
b) Estimate the solar radiation on a plate normal to the sun rays. Assume the sun to be a black body at a temperature of 5520°C . The diameter of the sun is $1.39 \times 10^6\text{ Km}$ and its distance from the earth is $1.5 \times 10^8\text{ km}$. [15]

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1. a) Write a short note on thermal conductivity of solids, liquids and gases.
 b) Identify the modes of heat transfer in the following systems:
 - i) Heat transfer from a room heater.
 - ii) Heat loss from a thermos flask.
 - iii) Drying of a wet hot plate in atmosphere.
 - iv) Condensation of steam in a condenser.
 - v) Boiling of water in a boiler. [15]

2. a) What are boundary and initial conditions?
 b) Write the mathematical formulation for the case of transient heat conduction through a solid cylinder of radius R initially at a temperature T_0 . The heat generated inside at a rate of $\bar{q}(w/m^3)$ is dissipated from the outer surface by convection into a medium at temperature T_∞ with a heat transfer coefficient h . [15]

3. a) A steel cylinder of diameter 0.25 m and length 0.8 m initially at 25°C is placed in a furnace where the temperature is 1000°C . Determine the temperature at the centre and on the surface of the cylinder after a lapse of 1 hr. (Assume thermal conductivity = 35 W/mk, density = 7800 kg/m³, specific heat = 0.83 kJ/kg k, heat transfer coefficient = 233 W/m²k).
 b) What is lumped system analysis? When is it applicable? [15]

4. a) Define Nusselt number and Prandtl number.
 b) A fluid at 27°C flows with a velocity of 10 m/s across a 5 cm outer diameter tube whose surface is kept at a uniform temperature of 120°C . Determine the average heat transfer coefficients and the heat transfer rates per meter length of the tube for:
 - i) Water
 - ii) ethylene glycol. [15]

5. a) Why are heat transfer coefficients for natural convection much less than those in forced convection?
 b) A vertical cylinder 5 cm diameter and 1 m high is maintained at a temperature of 65°C in atmosphere of air at 15°C . Calculate the rate of heat loss by free convection from the cylinder to air. [15]

6. a) Why is the heat transfer coefficient in nucleate boiling more than in film boiling?
- b) Water at atmospheric pressure is boiled in a kettle made of copper. The bottom of the kettle is flat, 30 cm in diameter and is maintained at a temperature of 118°C . Calculate the rate of heat required to boil water. Also estimate the rate of evaporation of water from the kettle. [15]
7. a) Discuss the advantages of NTU method over the LMTD method of heat exchanger design.
- b) Water at a rate of 7500 kg/hr enters a counter flow exchanger at 15°C to cool 8000 kg/hr of air at 105°C . The overall heat transfer coefficient is $145 \text{ W/m}^2\text{k}$ and the exchanger area is 20m^2 . Find the exit temperature of air. [15]
8. a) Distinguish between specular and diffuse surfaces.
- b) Two large parallel planes with emissivities of 0.3 and 0.5 are maintained at temperatures of 800°C and 300°C respectively. Determine the net radiant heat exchange per unit area between the planes. If a radiation shield having an emissivity of 0.05 on both sides is placed between the two planes, calculate the temperature of the shield and the heat transfer rate per unit area. [15]

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1. a) Explain the concept of thermal resistance. What are the practical uses of this concept?
b) Distinguish between free and forced convection with examples. [15]
2. a) Explain the significance of fin effectiveness and fin efficiency.
b) An electrical motor of 20 cm outside diameter and 50 cm height is provided with 12 number of longitudinal fins equally spaced in rectangular shape of 3 cm long and 0.3 cm thick. Calculate the amount of heat transferred, fin efficiency and effectiveness of the arrangement. Take thermal conductivity = 120 W/mk, heat transfer coefficient = $10\text{W/m}^2\text{k}$. Assume surface temperature of motor 100°C and surrounding temperature 30°C . [15]
3. a) What is the importance of Heisler charts?
b) A steel ball of 4 cm diameter initially at 200°C is placed in a water bath at 20°C with heat transfer coefficient = $100\text{W/m}^2\text{k}$. Calculate the time required for the center of sphere to reach a temperature of 40°C and the surface temperature at that time. Also find the amount of heat energy to be removed per minute from water to keep it at a constant temperature of 20°C . (Use thermal diffusivity = $6 \times 10^{-6}\text{m}^2/\text{sec}$, density = 7000kg/m^3 , specific heat = 460J/kg K , thermal conductivity = 40W/mk). [15]
4. a) Explain the procedure to form dimensionless groups by Buckingham – pi theorem.
b) Mach number of a flow of perfect gas depends on specific heat ratio r , pressure p , density ρ and velocity V . Obtain expression for mach number using dimensional method. [15]
5. a) Define Rayleigh number and explain its significance in natural convection.
b) Calculate the average coefficient of heat transfer for natural convection for a vertical plate 30 cm high at 50°C . The surrounding air is at 24°C . Also calculate the boundary layer thickness at the trailing edge of the plate. [15]
6. a) Distinguish between film wise and drop wise condensation. Which of the two gives a higher heat transfer coefficient? Why?
b) A 4cm outer diameter, 1 m long tube is to be used to condense steam at atmospheric pressure. The water flows inside the tube maintaining the wall surface at 60°C . Estimate the mass of condensate for the tube in horizontal position. [15]

7. a) How are heat exchangers classified?
- b) Determine the overall heat transfer coefficient based on the outer area of a 3.81cm O.D and 3.175 cm I.D. brass tube (thermal conductivity = 103.8 W/mk) if the heat transfer coefficients for flow inside and outside the tube are 2270 and 2840 W/m²k respectively. The unit fouling resistances at inside and outside surfaces are $R_{fi} = R_{fo} = 8.8 \times 10^{-3} \text{ m}^2 \text{ K/W}$. [15]
8. a) Define shape factor. Derive the expression for shape factor between two black bodies.
- b) What is Stefan Boltzman Law? Explain the concept of total emissive power of a surface. [15]

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