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QUESTION BANK

Details of the Course

Academic Year : **2026 – 2027**

Regulation **2024**

Course Code : **ME243503**

Name of the Course : **Heat and Mass Transfer**

Semester **V**

Common To Programme (s) : **-**

Course Outcome:

[CO1]-Apply heat conduction equations to different surface configurations under steady state and transient conditions and solve problems.

[CO2]-Apply free and forced convective heat transfer correlations to internal and external flows through/over various surface configurations and solve problems.

[CO3]-Explain the phenomena of boiling and condensation, apply LMTD and NTU methods of thermal analysis to different types of heat exchanger configurations and solve problems.

[CO4]-Explain basic laws for Radiation and apply these principles to radiative heat transfer between different types of surfaces to solve problems.

[CO5]-Apply diffusive and convective mass transfer equations and correlations to solve problems for different applications.

Bloom's Level: BL1-Remembering, BL2-Understanding, BL3-Applying, BL4-Analyzing, BL5–Evaluating, BL6-Creating.

S. No.	Instruction to be Followed
1.	Questions must be prepared according to the level (UG/PG) of the programme.
2.	Programme, Branch, Semester, Course Code, Course Title & Regulations must be verified.
3.	Question must conform to the syllabus & the End Semester Examination Question paper format.
4.	The marks assigned to each division / sub-division question must be mentioned against each question.
5.	The Bloom's Taxonomy knowledge level must be correctly mentioned for each question.
6.	All data, diagrams, symbols, repetition of questions, grammatical errors & spellings must be checked.
7.	The list of permitted data books, data sheets etc., & instructions to the candidates if any must be indicated in the Question paper (If needed)
8.	Each unit should have at least 10 Questions in Part A, 8 Questions in Part B, and 2 Questions in Part C. (In Part B, it is suggested to give two sub-divisions with first question focusing on theory and second question focusing on analytical part.)
9.	In Part C, the question should trigger the creative thinking of the students.
10.	For problematic courses, analytical questions can be considered in Part A, B and C.

Date: **Faculty In-charge** **HOD**

UNIT- I – CONDUCTION				
	PART – A (2 Marks)	**Bloom's Level**	**CO**	**Marks Allotted**
1.	Define heat transfer	BTL 1	[CO1]	[2]
2.	Define the thermal conductivity	BTL 1	[CO1]	[2]
3.	Define Fin or Extended surface	BTL 1	[CO1]	[2]
4.	State Fourier's law of conduction	BTL 2	[CO1]	[2]
5.	Equation for heat transfer through composite pipes or cylinder.	BTL 2	[CO1]	[2]
6.	What are the factors affecting the thermal conductivity	BTL 2	[CO1]	[2]
7.	Critical thickness of insulation with its significance.	BTL 3	[CO1]	[2]
8.	Lumped heat analysis and its applicable	BTL 3	[CO1]	[2]
9.	Analyzing and write down significance of Fourier number	BTL 4	[CO1]	[2]
10.	Analyzing and write down the significance for Biot number	BTL 4	[CO1]	[2]
Part B - (13 Marks)				
1.	Derive the general 3-dimensional conduction equation for cylindrical co-ordinates	BTL 1	[CO1]	[13]
2.	Derive the general 3-dimensional conduction equation for Rectangular co-ordinates	BTL 1	[CO1]	[13]
3.	A furnace wall is made up of three layer of thickness 25 cm, 10 cm and 15 cm with thermal conductivities of 1.65 W/mK and 9.2 W/mK respectively. The inside is exposed to gases at 1250^0c with a convection coefficient of 25 W/m2 K and the inside surface is at 11000c , the outside surface is exposed to air at 250C with convection coefficient of 12 W/m2K .Determine (i) the unknown thermal conductivity (ii)the overall heat transfer coefficient (iii)All the surface temperature.	BTL 5	[CO1]	[13]
4.	A steel pipe line(K=50W/mk) of I.D 110mm is to be covered with two layers of insulation each having a thickness of 50mm. The thermal conductivity of the first insulation material is 0.06W/mk and that of the second is 0.12W/mk. Calculate the loss of heat per metre length of pipe and the interface temperature between the two layers of insulation when the temperature of the inside tube surface is 250^0C and that of the outside surface of the insulation is 50 ^{0}C.	BTL 5	[CO1]	[13]
5.	A steel tube with 5 cm ID ,7.6 cm OD and k =15 W/m°C is convered with an insulative covering of thickness 2 cm and k = 0.2 W/m°C.A hot gas at 330°C with h= 400 W/m^2°C flow inside the tube.The outer surface of the insulation is exposed to cooler air at 30°C with h=60 W/m^2°C.Calculate the heat loss from the tube to the air for 10m of the tube and the temperature drops resulting from the thermal resistance of the hot gas flow ,the steel tube ,the insulation layer and the outside air.	BTL 5	[CO1]	[13]
6.	A cylinder 1m long and 5 cm in diameter is placed in an atmosphere at 450C . It is provided with 10 longitudinal straight finsof material having k=120W/mk.The height of 0.76mm thick fins is 1.27cm from the cylinder surface. The heat transfer co-efficient between cylinder and the atmospheric air is 17W/ m^{2}K.Calculate the rate of heat transfer and the temperature at the end of fins if the surface temperature of cylinder is 1500c.	BTL 5	[CO1]	[13]
Part C – (15 Marks)				
1.	A steel pipe of 120mm inner diameter, 140 mm outer diameter with thermal conductivity 55 W/mK is converted with two layers of insulation each having	BTL 5	[CO1]	[15]

	a thickness of 55 mm. The thermal conductivity of the first insulation material is 0.05W/mK and that of that of the second is 0.11W/mK. The temperature of the inside surface of the insulation is 60ºC. calculate the loss of heat per meter length of pipe and the interface temperature between the two layers of insulation			
2.	A circumferential rectangular profile fin on a pipe of 50mm outer diameter is 3mm thick and 20mm long.Thermal conductivity is 45 W/mK. Convecion co-efficient is 100 W/m^2K. Base temperature is 120ºC and surrounding air temperature is 35ºC. Determine 1. Heat flow rate per fin 2.Fin efficieny 3.Fin effectiveness.	BTL 5	[CO1]	[15]
UNIT- II – CONVECTION				
	PART – A (2 Marks)	**Bloom's Level**	**CO**	**Marks Allotted**
1.	Define the boundary layer thickness	BTL 1	[CO2]	[2]
2.	Define critical Reynolds number.	BTL 1	[CO2]	[2]
3.	Define grash off number and prandtl number. Write its significance	BTL 1	[CO2]	[2]
4.	What is means by forced convection	BTL 2	[CO2]	[2]
5.	What is meant by free or natural convection	BTL 2	[CO2]	[2]
6.	Why heat transfer coefficient for natural convection is much lesser than that for forced convection?	BTL 2	[CO2]	[2]
7.	Indicate the concept or significance of boundary layer	BTL 3	[CO2]	[2]
8.	Differentiate viscous sub layer and buffer layer.	BTL 3	[CO2]	[2]
9.	Name four dimensions used for dimensional analysis	BTL 4	[CO2]	[2]
10.	Why heat transfer coefficient for natural convection is much lesser than that for forced convection?	BTL 5	[CO2]	[2]
Part B - (13 Marks)				
1.	Explain in detail about the boundary layer concept.	BTL 3	[CO2]	[13]
2.	Air at 25°C at the atmospheric pressure is flowing over a flat plat at 3m/s.If the plate is 1m wide and the temperature T_W = 75°C. Calculate the Following at a location of 1m from leading edge. a) Hydro dynamic boundary layer thickness, b) Local friction coefficient, c) Thermal heat transfer coefficient, d) Local heat transfer coefficient.	BTL 3	[CO2]	[13]
3.	Air at 290°C flows over a flat plate at a velocity of 6 m/s. The plate is 1m long and 0.5 m wide. The pressure of the air is 6 KN/m2. If the plate is maintained at a temperature of 70°C, estimate the rate of heat removed from the plate.	BTL 6	[CO2]	[13]
4.	A large vertical plate 5 m height is maintained at 100°C and exposed to atmospheric air at 30°C. Calculate the Convective heat transfer coefficient.	BTL 5	[CO2]	[13]
5.	Air at 20°C at a pressure of 1 bar is flowing over a flat plate at a velocity of 3 m/s .if the plate is maintained at 60°C .Caiculate the heat transfer per unit width of the plate .Assuming the length of the plate along the flow of air in 2 m	BTL 5	[CO2]	[13]
6.	A large vertical plate 4m height is maintained at 606ºC and exposed to atmospheric air at 106ºC. Calculate the heat transfer if the plate is 10m wide.	BTL 5	[CO2]	[13]
Part C – (15 Marks)				

1.	A thin 100cm long and 10cm wide horizontal plate is maintained at a uniform temperature of 150ºC in a large tank full of water at 75ºC. Estimate the rate of heat to be supplied to the plate to maintain constant plate temperature as heat is dissipated from either side of plate.	BTL 5	[CO2]	[15]
2.	In condenser water flows through two hundred thin walled circular tubes having inner diameter 20mmand length6 m. the mass flow rate of water is 160 kg/s. the water enters at 30º C and leaves at 50ºC. Calculate the average heat transfer coefficient.	BTL 5	[CO2]	[15]
UNIT- III – PHASE CHANGE HEAT TRANSFER AND HEAT EXCHANGER				
	PART – A (2 Marks)	**Bloom's Level**	**CO**	**Marks Allotted**
1.	Define boiling and condensation	BTL 1	[CO3]	[2]
2.	Give the merits of drop wise condensation?	BTL 1	[CO3]	[2]
3.	Define the heat exchanger	BTL 1	[CO3]	[2]
4.	What is meant by compact heat exchangers?	BTL 2	[CO3]	[2]
5.	Write the application of boiling and condensation.	BTL 2	[CO3]	[2]
6.	What are the modes of condensation	BTL 2	[CO3]	[2]
7.	What is meant by regeneration?	BTL 2	[CO3]	[2]
8.	What is compact heat exchanger	BTL 2	[CO3]	[2]
9.	How does laminar flow differ from turbulent flow?	BTL 3	[CO3]	[2]
10.	Sketch the temperature variation in parallel and counter flow heat exchanger	BTL 3	[CO3]	[2]
Part B - (13 Marks)				
1.	Explain in detail about the different regimes of pool boiling with neat sketch.	BTL 3	[CO3]	[13]
2.	Water is to boil at atmospheric pressure in a polished copper pain by mean of an electric heater. The diameter of the pan is 0.38 m and is kept a 115C.Calculate the following (i) power required to boil the water. (ii) Rat of evaporation (iii) Critical heat flux.	BTL 5	[CO3]	[13]
3.	An aluminum pan of 15 cm diameter is used to boil water and the wate depth at the time of boiling is 2.5 cm.The pan placed on an electric stov and the heating element raises the temperature of the pan to 110°C.calculat the power input for boiling and the rate of evaporation take C_{sf} =0.0132	BTL 5	[CO3]	[13]
4.	Dry saturated steam at a pressure of 3 bar, condenses on the surface of a vertical tube of height 1m.The tube surface temperature is kept at 110°C. Calculate (i) Thickness of the condensate film. (ii) Local heat transfer co-efficient at a distance of 0.25 m.	BTL 5	[CO3]	[13]
5.	A condenser is to design, to condense 600 kg/h of dry saturated steam at a pressure of 0.12 bar. A square array of 400 tubes, each of 8 mm diameters is to be used. The tube surface is maintained at 30°C. Calculate the heat transfer co-efficient and the length of each tube.	BTL 5	[CO3]	[13]
6.	In a counter flow double pipe heat exchanger, water is heated from 25^0C to 65^0C by an oil with a specific heat of 1.45 kJ/kg K and mass flow rate of 0.9 kg/s. the oil is cooled from 230^0C to 160°C. If the overall heat transfer coefficient is 420 W/m^2K, calculate the following	BTL 5	[CO3]	[13]

	i. The rate of heat transfer ii. The mass flow rate of water iii. The surface area of the Heat exchanger			
	Part C – (15 Marks)			
1.	Classify the heat exchangers, derive the expression for effectiveness of parallel flow heat exchanger. **i)Analyze** how the temperature distribution of hot and cold fluids in a parallel flow heat exchanger influences its effectiveness when compared with a counter-flow heat exchanger.	BTL 6	[CO3]	[15]
2.	**Analyze** the physical mechanisms involved in **nucleate boiling, transition boiling, and film boiling**, highlighting the role of surface temperature, bubble formation, and heat flux.	BTL 6	[CO3]	[15]
	UNIT- IV – RADIATION			
	PART – A (2 Marks)	**Bloom's Level**	**CO**	**Marks Allotted**
1.	Define black body and gray body.	BTL 1	[CO4]	[2]
2.	Define irradiation and emissive power.	BTL 1	[CO4]	[2]
3.	Define Emissive power and monochromatic emissivity.	BTL 1	[CO4]	[2]
4.	State Lambert's cosine law.	BTL 2	[CO4]	[2]
5.	Define Emissivity.	BTL 1	[CO4]	[2]
6.	What is black body radiation?	BTL 2	[CO4]	[2]
7.	What are the factors involved in radiation by a body?	BTL 2	[CO4]	[2]
8.	What is thermal radiation? What is its wavelength band?	BTL 2	[CO4]	[2]
9.	What is the purpose of the radiation shield?	BTL 2	[CO4]	[2]
10.	Write down any two shape factor algebra.	BTL 3	[CO4]	[2]
	Part B - (13 Marks)			
1.	Calculate the following for an industrial furnace in the form of a black body and emitting radiation at 3000ºC. (i). Monochromatic emissive power at 1 μm wave length. (ii). Wavelength at which the emission is maximum (iii). Maximum emissive power, (iv). Total emissive power , (v). Total emissive power of the furnace if it is assumed as a real surface with emissivity equal to 0.85.	BTL 5	[CO4]	[13]
2.	The sun emits maximum radiation at λ=0.52μ .Assuming the sun to be a block body, calculate surface temperature of the sun , also calculate the monochromatic emissive power of the sun's surface	BTL 5	[CO4]	[13]
3.	Two parallel plates of size 3 m x 2 m are placed parallel to each other at a distance of 1 m. One plate is maintained at a temperature of 550°C and the other at 250°C and the emissivities are 0.35 and 0.55 respectively. The plates are located in a large room whose walls are at 35°C. If the plates located exchange heat with each other and with the room, calculate (i) Heat lost by the plates (ii) Heat received by the room	BTL 5	[CO4]	[13]
4.	Two black square plates of size 2 by 2 m are placed parallel to each other at a distance of 0.5 m. One plate is maintained at a temperature of 1000°C and the other at 500°C. Find the heat exchange between the plates	BTL 5	[CO4]	[13]

5.	Two circular discs of diameter 0.3 m each are placed 0.2 m apart. Calculate the radiant heat exchange for these discs if there are maintained at 750°C and 350°C respectively and the corresponding emissivities are 0.3 and 0.6.	BTL 5	[CO4]	[13]
6.	A gas mixture contains 20% CO_2 and 10% H_2O by volumes. The total pressure is 2 atm. The temperature of the gas is 927ºC. The mean beam length is 0.3 m. calculate the emissivity of the mixture.	BTL 5	[CO4]	[13]
Part C – (15 Marks)				
1.	Explain the fundamental laws governing thermal radiation. **Analyze how Planck's law forms the basis for Stefan–Boltzmann and Wien's displacement laws**, and discuss their practical significance in engineering applications involving high-temperature systems.	BTL 6	[CO4]	[15]
2.	Define **black body** and **gray body** radiation. **Analyze the differences in their radiative behavior** with respect to emissive power, absorptivity, and spectral distribution. Illustrate how real engineering surfaces are modeled using the gray body assumption.	BTL 6	[CO4]	[15]
UNIT- V – MASS TRANSFER				
	PART – A (2 Marks)	**Bloom's Level**	**CO**	**Marks Allotted**
1.	Give any two examples of mass transfer in day to day life.	BTL 1	[CO5]	[2]
2.	Define Lewis number.	BTL 1	[CO5]	[2]
3.	What is meant by mass transfer	BTL 2	[CO5]	[2]
4.	State Fick's law of diffusion	BTL 2	[CO5]	[2]
5.	What is molecular diffusion?	BTL 2	[CO5]	[2]
6.	What is eddy diffusion	BTL 2	[CO5]	[2]
7.	What is the convective mass transfer	BTL 1	[CO5]	[2]
8.	Compare the Reynolds analogy of heat transfer and mass transfer?	BTL 3	[CO5]	[2]
9.	Give example for free convective mass transfer.	BTL 3	[CO5]	[2]
10.	Give example for forced convective mass transfer.	BTL 2	[CO5]	[2]
Part B - (13 Marks)				
1.	A vessel contains a binary mixture of O_2 and N_2 with partial pressures in the ratio 0.21 and 0.79 at 20C.if the pressure of the mixture is 1.1bar,Calculate the following (i) molar concentrations (ii) mass densities (iii)mass fractions (iv) molar fraction of each spices	BTL 5	[CO5]	[13]
2.	The mixture weights of the two components A & B of the gas mixture are 24 and 48 respectively. The molecular weight of the gas. The molecular weight of the gas mixture is found to be 30. If the mass concentration of the mixture is 1.2 kg/m^3.determine the following (i) density of the components A and B (ii) molar fractions (iii) mass fraction (iv) total pressure if the temperature of the mixture is 200K.	BTL 5	[CO5]	[13]
3.	Ammonia and air in equimolar counter diffusion in a cylinder tube of 2.5 mm diameter and 1.5 m length. The total pressure is 1 atm and the temperature is 25°C. One end of the tube is connected to a large reservoir of the ammonia and the other end of the tube is open to atmosphere. If the mass diffusivity for the mixture is $0.28x10^{-4}$ m^2/s. calculate the following (i) mass rate of ammonia in kg/h (ii) mass rate of air in kg/h	BTL 5	[CO5]	[13]

4.	Air at 10°C with a velocity of 3 m/s flows over a flat plate. The plate is 0.3 m long. Calculate the mass transfer coefficient	BTL 5	[CO5]	[13]
5.	Hydrogen gases at 3 bar and 1 bar are separated by a plastic membrane having thickness 0.25 mm. the binary diffusion coefficient of hydrogen in the plastic is 9.1 x10^{-3} m^2/s. The solubility of hydrogen in the membrane is 2.1 x 10^{-3} a uniform temperature condition of 20°C is assumed. Calculate the following 1. Molar concentration of hydrogen on both sides 2. Molar flux of hydrogen 3. Mass flux of hydrogen	BTL 5	[CO5]	[13]
6.	An open pan 210 mm in diameter and 75 mm deep contains water at 25°C and is exposed to dry atmospheric air. Calculate the diffusion coefficient of water in air. Take the rate of diffusion of water vapour is 8.52 x10^{-4} kg/h.	BTL 5	[CO5]	[13]
Part C – (15 Marks)				
1.	Explain **transient (unsteady-state) diffusion**. **Analyze the differences between steady and transient diffusion**, and discuss the engineering significance of time-dependent concentration profiles.	BTL 6	[CO5]	[15]
2.	Explain the **basic concepts of mass transfer**. **Analyze the physical meaning of mass flux, concentration gradient, and diffusivity**, and discuss how these concepts govern diffusion in engineering systems.	BTL 6	[CO5]	[15]