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QUESTION BANK (DESCRIPTIVE)

Subject with Code : Advanced Heat Transfer (19ME3105) **Course & Branch**: M.Tech -ME

Year & Sem: I-M.Tech & II-Sem **Regulation:** R19

UNIT –I

Heat transfer, Steady State & Transient heat conduction

1		Derive general heat conduction equation in Cartesian co-ordinates	12M
2		What is 'Fourier's law of heat conduction'? State the assumptions on which this law is based?	12M
3		Derive a general heat conduction equation in cylindrical coordinates.	12M
4		Derive a general heat conduction equation in spherical coordinates	12M
5	a)	Explain the different modes of heat transfer with appropriate expressions	6M
	b)	What are Biot and Fourier numbers? Explain their physical significance?	6M
6		In a transfer type heat exchanger, heat is transferred from hot water at 90^0C on one side of a metal wall to cold air at 25^0C, on the other side. Thickness of the metal wall is 1 cm and its k = 20 W /m-K. If the surface area of the metal wall is $1m^2$, find the rate of heat transfer if the heat transfer coefficient on water and air side are 100 and 10 W/m^2K respectively. It is proposed to increase the heat transfer rate by providing fins on one side. On which side fins should be provided to get maximum heat transfer rate? If 500 fins of 6mm diameter and 30mm long are provided, find the maximum heat transfer rate achieved. Assume ends of fins are insulated.	12M
7		Two walls, 1m apart are connected by a metal rod of 2.5cm in diameter (k= 25W/m K). The temperature of one wall is 1000^0C and that of the other wall is 500^0C. A fluid of 300^0C is flowing through the space between the walls. The heat transfer coefficient of the fluid is 25 W/m^2 K. Find i) Find the heat transferred from the surface of the rod and ii) The position and value of minimum temperature in the rod.	12M
8	a)	Define transient, Non periodic and periodic heat conduction with examples?	06M
	b)	A 50cm x 50cm copper slab 6.25 mm thick has a uniform temperature of 300^0C. Its temperature is suddenly lowered to 36^0C. Calculate the time required for the plate to reach the temperature of 108^0C. Take ρ= 9000 kg/m^3, c= 0.38 kJ/ kg^0C; k= 370 W/ m^0C and h = 90 W/ $m^{2\ 0}$C	06M
9		A 60 mm thick large steel plate (k = 42.6 W/ m^0C and α = 0.043m^2 / h), initially at 440^0C is suddenly exposed on both sides to an environment with convective heat transfer coefficient 235 W/ m^2 ^{0}C and temperature 50^0C. Determine the center line temperature and temperature inside the plate 16Mm from the mid plane after 4.3 minutes. (DATA HANDBOOK ALLOWED)	12M
10	a)	A cylindrical ingot of 10cm diameter and 30cm long passes through a heat treatment furnace which is 6m in length. The ingot must reach a temperature	6M

		of 800^0C before it comes out of the furnace. The furnace gas is at 1250^0C and ingot initial temperature is 90^0C. What is the maximum speed with which the ingot should move the in the furnace to attain the required temperature? The combined radiative and convective surface heat transfer coefficient is 100 W/ m^2 ^{0}C. Take k(steel) = 40 W/ m^0C and α (thermal diffusivity of steel) = 1.16 x 10^{-6M2} / s.	
	b)	The aluminum square fins (0.6Mmx0.6Mm) of 1cm long provided on a surface of semi-conductor electronic device to carry 1W of energy generated by electronic device. The temperature at the surface of the device should not exceed 80^0C when the surrounding temperature is 40^0C. Find the number of fins required to carry out above duty. Neglect the heat loss from the end of fins. Take = k(aluminum)= 200 W/m^0C, h = 15 W/m^2 ^{0}C.	6M

UNIT –II

Forced Convection, Internal flows, Free convection

1		Explain hydrodynamic and thermal boundary layer with reference to flow over flat plate.	12M
2	a)	What is convective heat transfer? Distinguish between free and forced convection	6M
	b)	Derive the expression for Reynolds number and how flows are determined by Reynolds number?	6M
3		Derive three-dimensional general continuity equation in Cartesian coordinates.	12M
4		Derive momentum equation for hydrodynamic boundary layer over a flat plate.	12M
5		Derive expressions for boundary layer thickness and local skin friction coefficient following the Blasius method of solving laminar boundary layer equations for flat plate.	12M
6	a)	Define Nusselt number, Prandtl number and their significance.	6M
	b)	Air at atmospheric pressure and 200^0C flows over a plate with a velocity of 6M/s. The plate is 16Mm wide and is maintained at a temperature of 120^0C. Calculate the thickness of hydrodynamic and thermal boundary layers and the local heat transfer coefficient at a distance of 0.6M from the leading edge. Assume that flow is on one side of the plate. ρ=0.815kg/m^3; μ= 24.5 x 10^{-6} Ns/m^2; Pr = 0.7; k =0.0364W/m K	6M
7		Derive Approximate hydrodynamic boundary layer equation.	12M
8	a)	A vertical cylinder 1.6M high and 180mm in diameter is maintained at 100^0C in an atmosphere environment of 20^0C. Calculate heat loss by free convection from the surface of the cylinder. Assume properties of air at mean temperature as ρ = 1.06 kg/m^3,ν = 18.97 x 10^{-6} m^2/s, C_p = 1.004 kJ/kg^{0}C and k = 0.1042kJ/mh^{0}C	6M
	b)	Find the convective heat loss from a radiator 0.6m wide and 1.2m high maintained at a temperature of 90^0C in a room at 14^0C. Consider the radiator as a vertical plate.	6M
9		A 350 mm long glass plate is hung vertically in the air at 24^0C while its temperature is maintained at 80^0C. Calculate the boundary layer thickness at the trailing edge of the plate. If a similar plate is placed in a wind tunnel and air is blown over it at a velocity of 6M/s. Find the boundary layer thickness	12M

		at its trailing edge, Also determine the average heat transfer coefficient for natural and forced convection for the above mentioned data.	
10		Explain the concept of velocity distribution for a laminar flow through pipes with equation and neat sketches.	12M

UNIT –III

Boiling and condensation

1	a)	What are the unique features of boiling and condensation?	6M
	b)	What are the applications of boiling and condensation process?	6M
2	a)	Distinguish between i) Boiling and Condensation ii) Pool boiling and flow boiling	6M
	b)	A nickel wire 1mm diameter and 400 mm long, carrying current is submerged in a water bath which is open to atmospheric pressure. Calculate the voltage at the burn out point if at this point the wire carries a current of 190A.	6M
3		Explain in detail about boiling regimes with a neat sketch?	12M
4	a)	What are the factors affecting Nucleate boiling?	6M
	b)	Water at atmospheric pressure is to be boiled in polished copper pan. The diameter of the pan is 350 mm and is kept at 115^0C. Calculate the following i) Power of burner ii) Rate of evaporation in kg/h iii) Critical Heat flux	6M
5		Explain about film wise condensation and drop wise condensation?	12M
6		Derive the Nusselt theory of laminar flow film condensation on a vertical plate?	12M
7	a)	A wire of 1.2mm diameter and 200 mm length is submerged horizontally in water at 7 bar. The wire carries a current of 135 A with an applied voltage of 2.18 V. If the surface of the wire is maintained at 200^0C, calculate i) The heat flux ii) The boiling heat transfer coefficient	6M
	b)	A horizontal tube of outer diameter 20 mm is exposed to dry steam at 100^0C.The tube surface temperature is maintained at 84^0C by circulating water through it. Calculate the rate of formation of condensate per meter of the tube.	6M
8	a)	How does the surface tension influences the bubble size and shape?	6M
	b)	Water is boiled at the rate of 25 kg/h in a polished copper pan, 280mm in diameter, at atmospheric pressure. Assuming nucleate boiling conditions, calculate the temperature of the bottom surface of the pan.	6M
9		A vertical plate 350mm high and 420mm wide, at 40^0C, is exposed to saturated steam at 1atm. Calculate the following: i) The film thickness at the bottom of the plate ii) The maximum velocity at the bottom of the plate iii) The total heat flux to the plate Assume vapour density is small as compared to that of the condensate	12M
10		A 750mm square plate, maintained at 28^0C is exposed to steam at 8.132kPa. Calculate the following i)The film thickness, local heat transfer coefficient and mean flow velocity of condensate at 400 mm from the top of the plate.	12M

ii) The average heat transfer coefficient and total heat transfer from the entire plate.
iii) Total steam condensate rate and
iv) The heat transfer coefficient if the plate is inclined at 25^0C with the horizontal plane.

UNIT –IV

Heat Exchangers

1		What is a heat exchanger? How are heat exchangers classified?	12M
2	a)	Distinguish between regenerator and recuperator.	5 M
	b)	What is meant by LMTD? Write the assumptions to derive LMTD expression?	5 M
3		Derive an expression for LMTD in the case of parallel flow heat exchanger	12M
4		Derive an expression for LMTD in the case of counter- flow heat exchanger	12M
5	a)	What do you mean by fouling in heat exchangers? What are the different types of fouling processes?	6M
	b)	What are the parameters affecting fouling? How to prevent fouling in heat exchangers?	6M
6	a)	Define heat exchanger effectiveness. What are the common failures in heat exchangers?	6M
	b)	The flow rates of hot and cold water streams running through a parallel flow heat exchanger are 0.2 kg/s and 0.5 kg/s respectively. The inlet temperature on the hot and cold sides are 75^0C and 20^0C respectively. The exit temperature of hot water is 45^0C. If the individual heat transfer coefficients on both sides are 650W/m^2 ^{0}C. Calculate the area of heat exchanger.	6M
7		Derive the an expression for effectiveness by NTU method for parallel flow heat exchanger.	12M
8	a)	An oil cooler for a lubrication system has to cool 1000kg/h of oil (C_p = 2.09kJ/kg^{0}C) from 80^0C to 40^0C by using a cooling water flow of 1000kg/h at 30^0C. Give your choice for a parallel flow or counter flow heat exchanger, with reasons. Calculate the surface area of the heat exchanger, if the overall heat transfer coefficient is 24W/m^2 ^{0}C.	6M
	b)	The velocity of water flowing through a tube of 22m diameter is 2m/s. Steam condensing at 150^0C on the outside surface of the tube heats water from 15^0C to 60^0C over the length of the tube. Neglecting the tube and steam side film resistance, calculate the following: i) The heat transfer coefficient and ii) The length of the tube Properties of water at mean temperature: ρ = 900 kg/m^3, C_p = 4.2 kJ/kg^{0}C, k = 0.5418 W/m ^{0}C, $\mu = 700 \times 10^{-6}$ kg/ms	6M
9		16.5 kg/s of the product at 650^0C(C_p = 3.55 kJ/kg^{0}C) in a chemical plant are to be used to heat 20.5 kg/s of the incoming fluid from 100^0C(C_p = 4.2 kJ/kg^{0}C). If the overall heat transfer coefficient is 0.95 kW/m^2 ^{0}C and the installed heat transfer surface is 44m^2, calculate the fluid outlet temperatures for the counter flow and parallel flow arrangements.	12M
10		A counter flow heat exchanger is employed to cool 0.55 kg/s (C_p = 2.45 kJ/kg^{0}C) of oil from 115^0C to 40^0C by the use of water. The inlet and outlet temperatures of cooling water are 15^0C and 75^0C respectively. The overall	12M

heat transfer coefficient is expected to be 1450 $W/m^2\ {}^0C$. Using NTU method calculate the following:
i) The mass flow rate of water
ii) The effectiveness of the heat exchanger
iii) The surface area required.

UNIT –V

Radiation Heat Transfer

1	a)	What is Stefan Boltzmann Law? Explain the concept of total emissive power of a surface	6M
	b)	Assuming the sun to be a black body emitting radiation with maximum intensity at $\lambda = 0.49$ µm, Calculate the following: i) The surface temperature of the sun, and ii) The heat flux at the surface of the sun	6M
2	a)	State and explain Kirchhoff's identity. What are the conditions under which it is applicable?	6M
	b)	Distinguish between a black body and grey body.	6M
3		A thin aluminum sheet with an emissivity of 0.1 on both sides is placed between two very large parallel plates that are maintained at uniform temperatures T_1 = 800 K and T_2 = 500 K and have emissivity 0.2 and 0.7 respectively. Determine the net rate of radiation heat transfer between the two plates per unit surface area of the plates and compare the result to that without shield.	12M
4		Two very large parallel plates with emissivity 0.5 exchange heat. Determine the percentage reduction in the heat transfer rate if a polished aluminum radiation shield of emissivity = 0.04 is placed in between the plates.	12M
5	a)	Define emissivity, absorptivity and reflectivity.	6M
	b)	Derive Stefan - Boltzmann law.	6M
6		State and prove the following laws: i. Kirchoffs law of radiation ii. Stefan - Boltzmann law iii. Wien's law iv. Planks law	12M
7		Two circular discs of diameter 20 cm are placed 2m apart. Calculate the radiant heat exchange for these discs if these are maintained at 800°C and 300°C. respectively and their corresponding emissivity's are 0.3 and 0.5.	12M
8		Explain the concept of radiation exchange through radiation shields	12M
9		Consider two large parallel plates, one at 1000K with emissivity's 0.8 and the other is at 300K having emissivity 0.6 exchange heat by radiation. A radiation shield is placed between them having the emissivity of 0.1 on the side facing hot plate and 0.3 on the side facing cold side. Calculate the	12M

	percentage reduction in radiation heat transfer as a result of radiation shield.	
10	Determine the number of shields required to keep the temperature of the outside surface of a hollow brick lining of a furnace at 100^0C when the temperature inside surface of the lining is 500^0C. Take the emissivity of brick lining as well as for shield as 0.87. Heat transfer to the surroundings from the outer surface takes place by radiation and convection. The heat transfer coefficient for natural convection is given by $h_a = 1.44(\Delta t)^{0.33}$ W/m^2 ^{0}C, t_a(air temperature) =25^0 C. Neglect the heat transfer by conduction and convection between the brick lining.	12M

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