S. No	Question	Blooms Taxonomy Level	Program Outcome
UNIT – I			
PART – A (SHORT ANSWER QUESTIONS)			
1	How does the science of heat transfer differ from the science of thermodynamics?	Analyse	A B
2	What is the driving force for (a) heat transfer, (b) electric current flow, and (c) fluid flow?	Analyse	A
3	What is heat flux? How is it related to the heat transfer rate?	concept	A B
4	What are the mechanisms of energy transfer to a closed system? How is heat transfer distinguished from the other forms of energy transfer?.	concept	A
5	How are heat, internal energy, and thermal energy related to each other?	Evaluate	B
6	Define thermal conductivity and explain its significance in heat transfer	concept	A
7	What are the mechanisms of heat transfer? How are they distinguished from each other?	Evaluate	B
8	How does heat conduction differ from convection?.	Distinguish	c

S. No	Question	Blooms Taxonomy Level	Program Outcome
9	How does forced convection differ from natural convection?	Distinguish	F
10	Which is a better heat conductor, diamond or silver?	Analyse	F
11	What are the three modes of Heat Transfer? Explain their differences?	Analyse	A B
12	What does conduction refer to? State Fourier's law of heat transfer?	Analyse	A
13	How does the temperature in a cylindrical wall vary?	concept	A B
14	Define thermal conductivity. How can it be determined experimentally?	concept	A
15	Why are metals good thermal conductors, while non metals are poor conductors of heat?	Evaluate	B
16	State Fourier's law of heat conduction? why is the negative sign used?	concept	A
17	What is temperature gradient? Where it was used?	Evaluate	B
18	Explain the mechanism of heat conduction in glass, liquids and gasses?	Distinguish	c
19	How are Fourier's law and Ohm's law similar?	Distinguish	F
20	Explain the resistance concept to illustrate the analogy of heat flow and flow of electricity?		F

PART – B (LONGANSWER QUESTIONS)

S. No	Question	Blooms Taxonomy Level	Program Outcome
1	Distinguish between the basic laws of heat transfer with examples?	analyze	a
2	Discuss basic laws of 3 modes of heat transfer?	Discuss	a
3	Derive general conduction equation in Cartesian coordinates?	Derive	a
4	Derive conduction equation in cylindrical coordinates?	Derive	a
5	Derive conduction equation in spherical coordinate systems?	Derive	a
6	What are the applications of heat transfer?	Application	a
7	What are the different forms of heat transfer?	Describe	c
8	Describe different types of boundary conditions apply to heat conduction problem?	Analyze	B
9	Explain the concept of thermal diffusivity.	Knowledge	B
10	Explain the concept of convective mode of heat transfer	Knowledge	C
11	Explain the concept of radiation mode of heat transfer	Knowledge	C
12	What are the physical mechanisms of heat conduction in solid, liquid and gases?	Knowledge	B
13	Does any of the energy of the sun reach the earth by conduction or convection? Explain.	Knowledge	C
14	Consider heat transfer through a windowless wall of a house in a winter day. Discuss the parameters that affect the rate of heat conduction Through the wall.	Knowledge	C
15	How the thermal conductivity of liquids and gases vary with temperature. Explain.	Knowledge	C
16	Consider a person standing in a breezy room at 20°C. Determine	Analysis	B,C,D

S. No	Question	Blooms Taxonomy Level	Program Outcome
	the total rate of heat transfer from this person if the exposed surface area and the average outer surface temperature of the person are 1.6 m^2 and 29°C, respectively, and the convection heat transfer coefficient is 6 W/m^2 · °C		
17	Consider an alloy of two metals whose thermal conductivities are k_1 and k_2.will the thermal conductivity of the alloy be less than k_1, greater than k_2, or between k_1 and k_2.Explain.	Knowledge	A,B,C
18	Explain the concept of thermal resistance. On what parameters resistance depend upon.	Analyze	G
19	Why metals are good thermal conductors, while non-metals are poor conductors of heat? Explain with examples.	Knowledge	B
20	Explain the concept of overall heat transfer coefficient. Represent a thermal circuit with conduction and convection.	Knowledge	B
PART – C (ANALYATICAL QUESTIONS)			
1	An insulated pipe of 50 mm outside diameter (€=0.8) is laid in a room at 30 ^{0}C. If the surface temperatures is 250 ^{0} C and the convective heat transfer coefficient is 10 W/m^2K. Calculate the heat loss per unit length of pipe.	solve	a
2	Sheets of brass and steel each 1 cm thickness is in contact. The outer surface of brass is at 100 ^{0}C. And that of steel is at 0 ^{0} C. and K_b/K_s = 2 .Determine Interface temperature of sheets	solve	a
3	A steam pipe of (€=0.9) of 0.4 m diameter has a surface temperature of 500 ^{0}C.and is located in a large room at 25 ^{0} C where h =25 W/m.^{2}K. Find (i) Combined heat transfer coefficient (ii)The rate of heat loss per unit length	solve	a
4	If the combustion chamber wall is made up of Firebrick (k=0.145 W/m K,(€=0.85) and is 1.45 cm thickness, Compute the overall heat transfer coefficient for the following data.Gas temperature 800 ^{0}CWall temperature on gas side =798^{0}C film conductance on gas side 40 W /m^2K Film conductance on coolant side 10 W/m^2K	solve	a
5	The convective heat transfer coefficient h=2.512(Δ T)$^{0.25}$ W/m^2 K.A hot plate of A=0.2 m^2 at 59 ^{0}C losses heat to a room temperature 20 ^{0}C. Find the fraction of heat lost by natural convection when heat is transferred from the plate steadily at the rate of 100 W.	solve	A
6	The roof of an electrically heated home is 6 m long, 8 m wide, and 0.25 m thick, and is made of a flat layer of concrete whose thermal conductivity is k = 0.8 W/m · °C The temperatures of the inner and the outer surfaces of the roof one night are measured to be 15°C and 4°C, respectively, for a period of 10 hours. Determine (*a*) the rate of heat loss through the roof that night and (*b*) the cost of that heat loss to the home owner if the cost of electricity is $0.08/kWh.	solve	b
7	Consider a person standing in a breezy room at 20°C. Determine the total rate of heat transfer from this person if the exposed surface area and the average outer surface temperature of the person are 1.6 m^2 and 29°C, respectively, and the convection heat transfer coefficient is 6 W/m^2 · °C	solve	b
8	The ratio of radius of the earth‘s orbit to that of sun is 216.The solar insolation on the earth is 1.4W/m^2K.Find the surface temperature of the sun if it is assumed to be an ideal radiator (Blackbody).	Evaluate	G
9	A brick (k=1.2W/m K)wall 0.15m thick separates combustion gases in a furnace from the atmospheric air at 30 ^{0} C .The outer surface temperature is 100 ^{0}C while its emissivity is 0.8 and h=20w/m^2K.Determine the inner surface temperature of the brick wall.	Evaluate	

S. No	Question	Blooms Taxonomy Level	Program Outcome
10.	A pipe 2 cm in diameter at 30 ^{0} C is placed in (i) an air flow at 50^{0}C with h=20 W/m^{2}K and in (ii) water at 30 ^{0}C with h=70W/m^{2}K.Find the heat transfer rate per unit length of the pipe.	Evaluate	
	UNIT – II		
	PART – A (SHORT ANSWER QUESTIONS)		
1	How does transient heat transfer differ from steady heat transfer? How does one-dimensional heat transfer differ from two-dimensional heat transfer?	Analyse	a
2	From a heat transfer point of view, what is the difference between isotropic and anisotropic materials?	Analyse	e
3	What is heat generation in a solid? Give examples.	concept	e
4	What is a thermal symmetry boundary condition?	Analyse	e
5	A container consists of two spherical layers, A and B, that are in perfect contact. If the radius of the interface is r0, express the boundary conditions at the interface.	Evaluate	f
6	Does heat generation in a solid violate the first law of thermodynamics, which states that energy cannot be created or destroyed? Explain	Understand	f
7	Is the thermal conductivity of a medium, in general, constant or does it varies with temperature?	Understand	g
8	How is the combined heat transfer coefficient defined? What convenience does it offer in heat transfer calculations?	Understand	g
9	What is thermal contact resistance? How is it related to thermal contact conductance?	concept	e
10	What is the difference between the fin effectiveness and the fin efficiency	Distinguish	E
11	What is lumped system analysis?	concept	A
12	When is lumped system analysis it applicable?	application	A
13	In what medium is the lumped system analysis more likely to be applicable: in water or in air? Why?	analyse	A B
14	Obtain relations for the characteristic lengths of a large plane wall of thickness 2L, a very long cylinder of radius ro, and a sphere of radius ro.	Analyse	C
15	What is an infinitely long cylinder?	concept	AF
16	Define Biot number	define	AF
17	What is the physical significance of the Fourier number?	Evaluate	A F
18	Why are the transient temperature charts prepared using non dimensionalized quantities such as the Biot and Fourier numbers instead of the actual variables such as thermal conductivity and time?.	Evaluate	F
19	What is a semi-infinite medium? Give examples of solid bodies that can be treated as semi-infinite mediums for heat transfer purposes?	Analyse	f
20	Under what conditions can a plane wall be treated as a semi-infinite medium?	analysis	F
	PART – B (LONG ANSWER QUESTIONS)		
1	Derive one dimensional steady state conduction equation in case of slab	derive	e
2	Explain the following (i) Log mean area (ii)geometric mean area	Explain	g
3	What is critical thickness of insulation explain	Define	e
4	Derive the conduction in one-dimensional case for a	Derive	f

S. No	Question	Blooms Taxonomy Level	Program Outcome
	cylinder		
5	What are the assumptions for heat transfer analysis in case of fins	analyze	e
6	Derive the expression for heat transfer in fins in case of (i)Rectangular plate fin of uniform cross section (ii)insulated end.	Derive	e
7	Define fin and explain different types of fins.	Estimate	f
8	Explain briefly (i)Fin effectiveness (ii) Fin efficiency	Explain	e
9	Explain the heat transfer analysis in composite wall.	evaluate	e
10	Derive expression for critical thickness of insulation for a cylinder.	Derive	F
11	Under what conditions the systems are said to be lumped heat systems. Explain	Understanding	A
12	Explain the concept of lumped analysis.	Explain	A B
13	Derive the expression for heat transfer under transient mode	derive	G
14	Define Biot number and Fourier number .What is their importance in heat transfer. Explain.	Define	F
15	Explain how biot number help in transient conduction problem	Application	F
16	What are heisleir charts? Under what conditions heislier charts are used in heat transfer problems.	Application	F
17	Enumerate steps for solving long cylinders using heislier charts	analysis	A F
18	Enumerate steps for heat transfer analysis in slabs using heislier charts.	analysis	B F
19	A Thermocouple, the junction of which can be approximated as a 1mm diameter of a gas stream. The properties of the junction are ρ =8500kg/m^3, c=320J/kg K and k=35W/m K. The heat transfer coefficient between the junction and the gas is 210W/m^{2}K. Determine how long it will take for the thermocouple to read 99% of the initial temperature difference.	Determine	BF G
20	A Steel tube of length 20cm with internal and external diameters of 10 and 12cm is quenched from 500^0 C to 30^{0}C in a large reservoir of water at 10^{0}C it is less owing to a film of vapour being produced at the surface, and an effective mean value between 500^{0}C and 100^{0}C is 0.5kW/m^2. the density of steel is 7800kg/m^3 and the specific heat is 0.47kJ/kg K. neglecting internal thermal resistance of the steel tube, determine the quenching time	Determine	BF G
PART – C (ANALYTICAL QUESTIONS)			
1	A Hollow heat cylinder with r_1=30 mm and r_2=50 mm , k=15W/mK is heated on the inner surface at a rate of 10 ^{5} W/m^2 and dissipates heat by conduction from the outer surface to a fluid at 100 ^{0}C with h=400 W/m^{2}K. Find the temperature inside and outside surfaces of the cylinder. and also find rate of heat transfer through the wall	solve	f
2	A tube 2 cm. O.D maintained at uniform temperature of Ti is covered with insulation (k=0.20 W/m K) to reduce heat loss to the ambient air Tα with h_a=15W/m^{2}K. Find i) the critical thickness r_c of insulation (ii)the ratio of heat loss from the tube with insulation to that without insulation, (a) if the thickness of insulation is equal to r_c	solve	f
3	Three 10cm dia rods A,B and C protrude from a steam bath at 100 ^{0}C to a length of 25cm into an atmosphere at 20 ^{0}C. The temperature at the other end are T_a=26.76^{0}C, T_b=32^{0}C and T_c=36.93^{0}C. Find the thermal conductivities of the rod A, B and C, if h=23W/m^{2}K	solve	g

S. No	Question	Blooms Taxonomy Level	Program Outcome
	in each case.		
4	A stainless steel fin (k=20W/m K) having a diameter of 20 mm and a length of 0.1 m is attached to a wall at 300^0C. The ambient temperature is 50^0C and the heat transfer coefficient is 10 W/m K. The fin tip is insulated. Determine (a) the rate of heat dissipation from the fin, (b) the temperature at the fin tip, (c) the rate of heat transfer from the wall area covered by the fin was not used and (d) the heat transfer rate from the same fin geometry if the stainless steel fin is replaced by a fictitious fin with infinite thermal conductivity	solve	f
5	Two large steel plates at temperatures of 120^0C and 80^0C are separated by a steel rod 300 mm long and 25mm in diameter. The rod is welded to each plate. The space between the plates is filled with insulation, which also insulates the circumference of the rod. Because of a voltage difference between the two plates, current flows through the rod, dissipating electrical energy at a rate of 150W. Find out the maximum temperature in the rod and the heat flux. Take k for the rod as 47 W/m K.	solve	f
6	A cylinder steel ingot (diameter 100mm, length 300mm, k=40W/m K, ρ =7600kg/m^3 and c=600J/kg K) is to be heated in a furnace from 50^0C to 850^0C. The temperature inside the furnace is 1300^0C and the surface heat transfer coefficient is 100W/m^2 K. calculate the time required for heating	solve	f
7	Determine the heat transfer rate from the rectangular fin of length 20 cm , width 40 cm and thickness 2 cm .The tip of the fin is not insulated and the fin has a thermal conductivity of 150 W/m K. The base temperature is 100 ^{0}C and the fluid is 20 ^{0}C .The heat transfer coefficient between the fin and the fluid is 30 W/m^2K	solve	g
8	A copper fin (k=396 W/m K) 0.25 cm in diameter protrudes from a wall at 95 ^{0}C into ambient air at 25 ^{0}C.The heat transfer coefficient by free convection is equal to 10 W/m^2K.Calculate the heat loss if (a) The fin is infinitely long (b)The fin is 2.5 cm long and the coefficient at the end is same as around the circumference	solve	g
9	A solid sphere of radius 0.5 m has an internal heat generation rate of 2x10 ^{6} W/m^3.If the thermal conductivity of material is 40 W/mK and the convective heat transfer coefficient at the surface of sphere is 100 W/m^2K. Calculate the temperatures at the outer surface and at the center. Take ambient temperature as 30 ^{0}C.	solve	g
10	Steel ball bearing (k=50W/m K, α=1.3x10^{-5} m^2/s) having a diameter of 40mm are heated to a temperature of 650^0C and then quenched in a tank of oil 55^0C. If the heat transfer coefficient between the ball bearings and oil is 300W/m^2 K, determine (a) the duration of time the bearings must remain in oil to reach a temperature of 200^0C, (b) the total amount of heat removed from each bearing during this time and (c)the instantaneous heat transfer rate from the bearings when they are first immersed in oil and when they reach 200^0C.	Evaluate	C
	UNIT - III		
	PART – A (SHORT ANSWER QUESTIONS)		
1	What is forced convection? How does it differ from natural convection? Is convection caused by winds forced or natural convection?	concept	A F

S. No	Question	Blooms Taxonomy Level	Program Outcome
2	What is the physical significance of the Nusselt number? How is it defined	evaluate	A G
3	Define incompressible flow and incompressible fluid. Must the flow of a compressible fluid necessarily be treated as compressible?	concept	B F
4	How does turbulent flow differ from laminar flow? For which flow is the heat transfer coefficient higher?	evaluate	B F
5	What is the physical significance of the Reynolds number? How is it defined for external flow over a plate of length L?.	analyse	F
6	What is turbulent thermal conductivity? What is it caused by?	evaluate	F
7	State Newtons law of cooling Is the acceleration of a fluid particle necessarily zero in steady flow? Explain.	concept	A C
8	What are the advantages of non dimensionalizing the convection equations?	analyse	F
9	How is Reynolds analogy expressed? What is the value of it? What are its limitations?	Evaluate	F
10	What is drag? What causes it? Why do we usually try to minimize it?	concept	A D
11	What is natural convection? How does it differ from forced convection? What force causes natural convection currents?	concept	A F
12	In which mode of heat transfer is the convection heat transfer coefficient usually higher, natural convection or forced convection? Why	evaluate	A G
13	How does the Rayleigh number differ from the Grashof number	concept	B F
14	Consider laminar natural convection from a vertical hot plate. Will the heat flux be higher at the top or at the bottom of the plate? Why?	evaluate	B F
15	Show that the volume expansion coefficient of an ideal gas is 1/T, where T is the absolute temperature.	analyse	F
16	Why are finned surfaces frequently used in practice? Why are the finned surfaces referred to as heat sinks in the electronics industry?	evaluate	F
17	When is natural convection negligible and when is it not negligible in forced convection heat transfer?	concept	A C
18	When neither natural nor forced convection is negligible, is it correct to calculate each independently and add them to determine the total convection heat transfer?	analyse	F
19	Under what conditions does natural convection enhance forced convection, and under what conditions does it hurt forced convection?	Evaluate	F
20	Why are heat sinks with closely packed fins not suitable for natural convection heat transfer, although they increase the heat transfer surface area more?	concept	A D
PART – B (LONG ANSWER QUESTIONS)			
1	Differentiate between Newtonian and Non Newtonian fluids. Give examples	Discuss	A
2	What is boundary layer thickness what do you mean by laminar and turbulent boundary layers.	Evaluate	G
3	What is critical Reynolds number for flow over flat plate? Explain.	Evaluate	F
4	Define local and mean heat transfer coefficient. On what factors 'h' value depends on	Analyse	F
5	A metal plate 0.609 m in height forms the vertical wall of an oven and is at a temperature of 171^{0}C. Within the oven is air at a	calculate	F

S. No	Question	Blooms Taxonomy Level	Program Outcome
	temperature of 93.4^0C and the atmospheric pressure. Assuming that natural convention conditions hold near the plate, and that for this case $Nu=0.548(Gr\ Pr)^{1/4}$ find the mean heat transfer coefficient and the heat taken up by air per second per meter width. For air at 132.2^0C, take $k=33.2x10^{-6}$kW/m, $\mu=0.232x10^{-4}$kg/ms, $c_p=1.005$kJ/kg K. Assume air as an ideal gas and R=0.287kJ/kg K.		
6	A 0.15m outer diameter. steel pipe lies 2m vertically and 8m horizontally in a large room with an ambient temperature of 30^0C. The pipe surface is at 250^0C and has an emissivity o f 0.60. Estimate The total rate of heat loss from the pipe to the atmosphere	solve	C
7	A nuclear reactor with its core constructed of parallel vertical plates 2.2n high and 1.45m wide has been designed on free convention heating of liquid bismuth. The maximum possible heat dissipation from both sides of each plate. For the convention coefficient the appropriate correlation is $Nu=0.13(Gr.Pr)^{1/3}$ where the properties evaluated at the mean film temperature of 650^0C for bismuth are: $\rho=10^4 kg/m^3$, $c_p=150.7$J/kg K, k=13.02W/m K.	solve	C
8	State Buckingham pi theorem .What are the merits and demerits	Describe	A B D
9	What do you mean by VonKorman 's integral method. and derive drag force and heat transfer coefficient for flow over a flat plate	Understanding	G F
10	Explain Reynold's analogy. Derive an expression for it.	Understanding	A F
11	What is physical significance of Grashoff number Derive $\beta=1/T$	significance	F
12	Explain the concept of Nusselt's theory of laminar flow	Explain	F
13	Explain the conditions for which Dittus-Boelter equation can be used to determine heat transfer coefficient	Explain	C
14	What is Rayleigh number? Discuss the nature of flow with respect to it.	Define	F
15	What do you mean by hydrodynamic entry length?	Define	D
16	Give the steps to find heat transfer in natural convection.	Analyse	C E
17	Air at 1atm and 30^0C is forced through a horizontal 30mm diameter 0.5m Long at an average velocity of 0.25m/s. The tube wall is maintained at 137^0C. Calculate (a) the heat transfer coefficient and (b) percentage error if the calculation is made strictly on the basis of laminar forced convention	Apply	C
18	Engine oil at 60°C flows over the upper surface of a 5-m-long flat plate whose temperature is 20°C with a velocity of 2 m/s Determine the total drag force and the rate of heat transfer per unit width of the entire plate	evaluate	F
19	A square plate 0.4mx0.4m maintained at a uniform temperature of T_w=400K is suspended vertically in quiescent atmospheric air at 27^0C. Determine (a)the boundary layer thickness at the trailing edge of the plate(i.e. at x=0.4m),(b)the average heat coefficient over the entire length by using theoretical analysis .Properties of air at 35^0 K are $\nu=2.075x10^{-6}m^2/s$, Pr=0.697 and k= 0.03W/m K.	solve	C
20	A 2.2cm outer diameter pipe is to cross a river at a 30mwide section while being completely immersed in water The average flow velocity of water is 4 m/s and the water temperature is 15^0C.	apply	B

S. No	Question	Blooms Taxonomy Level	Program Outcome
	Determine the drag force exerted on the pipe by the river.		
	PART – C (ANALYTICAL QUESTIONS)		
1	Nitrogen gas at 0^0C is flowing over a 1. 2m long,2m wide plate maintained at 80^0C with a velocity of 2.5m/s., ρ=1.142kg/m^3 ,c_p=1.04kJ/kg K, ν=15.63x$10^{-6}$$m^2$/s and k=0.0262W/m K. Find (a) The average coefficient and (b)the total heat transfer from the plate.	Understanding	C
2	Water at 10^0C flows over a flat plate (at 90^0C) measuring 1mx1m, with a velocity of 2m/s .properties of water at 50^0C are ρ =988.1^0C, ν=0.556x$10^{-6}$$m^2$/s, Pr=3.54 and k=0.648W/m K. find: (a)The length of plate over which the flow is laminar, (b)the rate of heat transfer from the entire plate..	Apply	F
3	Water flows through a 20mm ID at a rate of 0.01kg/s entering at 10^0C. Thetube is wrapped from outside by an electric element that produces a uniform flux of 156kW/m^2.If the exit temperature of water is 40^0C, estimate (a)the Reynolds number,(b)the heat transfer coefficient, (c)the length of the pipe needed, (d)the inner tube surface temperature at exit, (e)the friction factor, (f)the pressure drop in the tube, and (g)the pumping power required if the pump efficiency is 60%. Neglect entrance effects. Properties of water at mean temperature of 25^0C are: ρ =997kg/m^3, c_p=4180J/kg K, ν=910x10^{-6}Ns/m^2 and k=0.608W/m K.	Apply	B
4	It was found during a test in which water flowed with a velocity of 2.44m/s through a tube (2.54cm inner diameter and 6.08m long), that the head lost due to friction was 1.22m of water. Estimate the surface heat transfer coefficient based on Reynolds analogy. Take ρ =998kg/m^3 and c_p=4.187kJ/kg K	solve	C
5	Atmospheric pressure air at 100^0c enters a 0.04m dia 2m long tube with a velocity of 9m/s. A 1kW electric heater wound on the surface of the outer surface of the tube provides a uniform heat flux to the tube. find (a)The mass flow rate of air, (b)the exit temperature of air, and (c)the wall temperature of tube at outlet.	solve	C
6	Lubricating oil (ρ =865kg/m^3, k=0.14W/m K and c_p=1.78kJ/kg K and ν=9x$10^{-6}$$m^2$/s) at 60^0C enters a 1cm dia tube with a velocity of 3.5m/s. T_w=30^0C, constant. Find The tube length required to cool the oil to 45^0C.	solve	C
7	For the flow system in which air at 27^0C and 1atm flows over a flat plate at a velocity of 3m/s, estimate the drag force exerted on the 45cm of the plate using the analogy between fluid friction and heat transfer.	solve	C
8	Air at 2atm and 200^0C is heated as it flows at a velocity of 12m/s through a tube with a diameter of 3cm. A constant heat flux condition is maintained at the wall and the wall temperature is 20^0C above the air temperature all along the length of the tube. Calculate (a) the heat transfer per unit length of tube. Properties of air at 200^0C are Pr=0.681, μ=2.57x10^{-5}kg/ms, k=0.0386W/m K and c_p=1.025kJ/kg K.	solve	C
9	Air at 1atm, 27^0C flow across a sphere of 0.015m dia at a velocity of 5m/s.A heater inside the sphere maintains the surface temperature at 77^0C. Find the rate of heat transfer from the sphere.	solve	C
10	Water flows at a velocity of 12m/s in a straight tube of 60mm diameter. The tube surface temperature is maintained at 70^0C and the flowing water is heated from the inlet temperature of 15^0C to an outlet temperature of 45^0C. Taking the physical properties of water at the bulk temperature of 30^0C as ρ=995.7kg/m^3, c_p=4.174kJ/kg K, k=61.718x10^{-2}W/m K, ν=0.805x$10^{-6}$$m^2$/s and Pr=5.42, Calculate (a)the heat surface coefficient from the tube surface to the water,	apply	B

S. No	Question	Blooms Taxonomy Level	Program Outcome
	(b)the heat transferred and (c)the length of the tube.		
UNIT - IV			
PART – A (SHORT ANSWER QUESTIONS)			
1	What is the difference between evaporation and boiling?	Evaluate	A
2	What is the difference between sub cooled and saturated boiling?	concept	B
3	Name the different boiling regimes in the order they occur in a vertical tube during flow boiling	concept	f
4	What is the difference between film and dropwise condensation? Which is a more effective mechanism of heat transfer?	distinguish	f
5	In condensate flow, how is the wetted perimeter defined? How does wetted perimeter differ from ordinary perimeter	concept	F
6	What is the modified latent heat of vaporization? For what is it used? How does it differ from the ordinary latent heat of vaporization?	concept	G
7	What is condensation? How does it occur?	Apply	A B
8	How does the presence of a noncondensable gas in a vapor influence the condensation heat transfer?	Evaluate	D
9	Name the different boiling regimes in the order they occur in a vertical tube during flow boiling	phenomena	D
10	Discuss some methods of enhancing pool boiling heat transfer permanently.	Concept	C
11	What is an electromagnetic wave? How does it differ from a sound wave?.	Evaluate	A
12	What is thermal radiation? How does it differ from the other forms of electromagnetic radiation?.	concept	AB
13	What is a blackbody? Does a blackbody actually exist?	concept	B
14	Why did we define the blackbody radiation function? What does it represent? For what is it used?	Application	B
15	What does a solid angle represent, and how does it differ from a plane angle? What is the value of a solid angle associated with a sphere?	analysis	C B
16	Define the properties emissivity and absorptivity. When are these two properties equal to each other?	Define	F E
17	What is a graybody? How does it differ from a blackbody? What is a diffuse gray surface?	Define	E
18	What does the view factor represent? When is the view factor from a surface to itself not zero?	Evaluate	B F
19	What are the summation rule and the superposition rule for view factors?	concept	B D F
20	What are the two methods used in radiation analysis? How do these two methods differ?	Describe	F A
PART – B (LONG ANSWER QUESTIONS)			
1	What r the assumptions to be considered for analysis of laminar film condensation	Assumptions	A B
2	Derive the expression for condensation heat transfer.	Derive	F
3	Explain different regimes of boiling heat transfer phenomena	Explain	E
4	Explain drop wise and film wise condensation	Explain	A B
5	Why the condenser tubes are horizontal	analyse	A

S. No	Question	Blooms Taxonomy Level	Program Outcome
6	What is nucleate boiling explain	Explain	F
7	Explain film boiling explain	Explain	F
8	Write the correlations for boiling heat transfer incase of nucleate bioling	Enumerate	F G
9	Differentiate between different types of condensers	Differentiate	B D
10	Write correlations for condensation heat transfer ..	enumerate	F
11	Explain what do you mean by absorptivity ,reflectivity and transmissivity	analyse	A B
12	Define Opaque body and black body	Define	A
13	Define momochromatic emissive power and total emissive power	Define	A
14	What are the basic laws of radiation.	Analyse	B C
15	What is shape factor obtain the expression for it	Evaluate	A
16	Derive expression for radiant energy between two small gray surfaces	Evaluate	A
17	Explain radiosity	Evaluate	B
18	Explain irradiation	concept	C
19	Write expression for monochromatic emissive power	Expression	G
20	Write expression for blackbody radiation. ..	Expression	G
PART – C (ANALYTICAL QUESTIONS)			
1	Saturated steam at 54.5^{0}C condenses on the outside surface of a 25.4mm outer diameter 3.66m long vertical tube maintained at a uniform temperature of 43.3^{0}C. Because of the occurrence of ripples on the surface of the condensate film the actual heat transfer coefficient 20% higher than the obtained by Nusselt's equation. Determine the average condensation heat transfer coefficient over the entire length of the tube and the rate of condensate flow at the bottom of the tube. Check that the flow is laminar. The properties of condensate at 48.9^{0}C are h_{fg}=2372.4kJ/kg K, k=0.642W/m K, ρ =988.4kg/m^3 and μ =0.558x10^{-3}kg/m s.	solve	A
2	Saturated steam at 110^{0}C condenses on the outside of a bank of 64 horizontal tubes of 25mm outer diameter; 1m long arranged 8x8 square arrays. Calculate the rate of condensation if the tube surface is maintained at 100^{0}C. The properties of saturated water at 105^{0}C are ρ=654.7kg/m^3, k=0.684W/m^2 K, μ =271x10^{-6} Kg/mS and h_{fg}=2243.7kJ/kg.	solve	G
3	A Vertical plate 300mm wide and 1.2m high is maintained at70^{0}C and is exposed to saturated steam at 1atm pressure. Calculate the heat transfer coefficient and the total mass of steam condensed per hour. What would be the heat coefficient if the plate is inclined at 30^{0}C to the vertical?	solve	G
4	Estimate the power required to boll water in a copper pan, 0.35m in diameter. The pan is maintained at 120^{0}C by an electric heater. What is the evaporation rate? Estimate the critical heat flux	solve	G
5	A metal-clad heating element of 8mm diameter and emissivity 0.9 is horizontally immersed in a water bath. The surface temperature of the metal is 260^{0}C under steady-state boiling conditions. Estimate the power dissipation per unit length of heater	apply	B
6	Water is to be boiled at atmospheric pressure in a mechanically polished stainless steel pan placed on top of a heating unit, The inner	solve	G

S. No	Question	Blooms Taxonomy Level	Program Outcome
	surface of the bottom of the pan is maintained at 108°C. If the diameter of the bottom of the pan is 30 cm, determine (*a*) the rate of heat transfer to the water and (*b*) the rate of evaporation of water		
7	A black body emits radiation at 2000K. Calculate (i) the monochromatic emmissive power at 1 µ.m wavelength,(ii) wavelength at which the emission is maintained and (iii)the maximum emmissive power	solve	B
8	The filament of a 75W light bulb may be considered a black body radiating into a black enclosure at 70^0C. the filament diameter is 0.10mm and the length is 50mm. Considering the radiation, determine the filament temperature.	solve	B
9	An enclosure measures 1.5mx1.7m with a height of 2m. The walls and ceiling are maintained at 250^0C and the floor at 130^0C. The walls and ceiling have an emissivity of 0.82 and the floor 0.7.Determine the net radiation to the floor.	solve	B
10	Two black discs 1m in diameter are placed directly opposite to each other at a distances 0.5m.The discs are maintained at 1000K and 500K respectively. Calculate the heat flow between the discs (a) when no other surfaces are present and (b)when the discs are connected by a cylindrical refractory no- flux surface	solve	C
UNIT - V			
PART – A (SHORT ANSWER QUESTIONS)			
1	Classify heat exchangers according to flow type and explain the characteristics of each type.	classify	A
2	Classify heat exchangers according to construction type and explain the characteristics of each type.	classify	A
3	What is a regenerative heat exchanger? How does a static type of regenerative heat exchanger differ from a dynamic type?	concept	B
4	What are the heat transfer mechanisms involved during heat transfer from the hot to the cold fluid?	Application	C
5	Draw a 2-shell-passes and 8-tube-passes shell-andtube heat exchanger. What is the primary reason for using so many tube passes?	design	D
6	What are the common causes of fouling in a heat exchanger? How does fouling affect heat transfer and pressure drop?	concept	F
7	How is the thermal resistance due to fouling in a heat exchanger accounted for? How do the fluid velocity and temperature affect fouling?	create	B
8	Can the logarithmic mean temperature difference Tlm of a heat exchanger be a negative quantity? Explain	Evaluate	C
9	When the outlet temperatures of the fluids in a heat exchanger are not known, is it still practical to use the LMTD method? Explain.	derive	B
10	What are the common approximations made in the analysis of heat exchangers?	derive	D
11	What is a heat exchanger? What are its applications?	Application	A

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12	Give the three broad classes of heat exchangers?	classify	A
13	What is direct contact type heat exchanger? Give examples?	concept	B
14	What is compact Heat exchanger, what are its applications?	Application	C
15	What do you understand by mixed flow and unmixed flow?	design	D
16	What is multi pass heat exchanger? Where they are used?	concept	F
17	Explain about storage type heat exchanger? What are its applications?	Application	B
18	What are the different flow arrangements in recuperative heat exchangers?	Evaluate	C
19	Explain the operation of a plate heat exchanger? What are its applications?	Application	B
20	Define effectiveness and NTU of a heat exchanger?	Define	F E
PART – B (LONG ANSWER QUESTIONS)			
1	Classify heat exchangers	Classify	A
2	What are the applications of heat exchangers..	Applications	B
3	What do you mean by fouling factor..causes of fouling	Define	C
4	What are shell and tube heat exchangers?	Analyse	A
5	Derive LMTD for parallel flow heat exchangers	Derive	E
6	Derive LMTD for counter flow heat exchangers	Derive	E
7	Define effectiveness and NTU ,;mmk of heat exchanger	Define	E
8	Derive expression for effectiveness of parallel flow heat exchanger	Evaluate	E
9	Derive expression for effectiveness of counter flow heat exchanger	Evaluate	E
10	Derive NTU of parallel flow and counter flow heat exchangers. ..	Evaluate	E
11	In the definition of effectiveness, explain why minimum heat capacity value (C_{min}) is used for the maximum possible rate of heat transfer.	Derive	C
12	Show that for paraller flow heat exchanger ε=[1-exp(-NTU(1+R)]/[1+R]	Derive	C
13	Show that for paraller flow heat exchanger ε=[1-exp(-NTU(1-R)]/[1-R exp(-NTU(1-R]	Derive	C
14	How are exit fluid temperature determined with the help of ε-NTU method?	Analyse	A
15	When on of the two fluids undergoes phase change, show that the effectiveness values for both parallel flow and counter flow heat exchangers are eual and given by ε=1-exp(-NTU)	Derive	C
16	In an oil cooler, oil enters at 160^{0}C. If the water entering at 35^{0}C flows parallel to oil, the exit temperatures of oil and water are 90^{0}C and 70^{0}C respectively. Determine the exit temperatures of oil and water if the two fluids in opposite directions. Assuming that the flow rates of the two fluids and U_0 remain unaltered. What would be the minimum temperatures to which oil could be cooled in parallel flow and counter flow operations?	creating	B
17	In an open heart surgery under hypothermic conditions, the patient's blood is cooled before the surgery and re warmed afterwards. It is proposed that a concentric tube counter flow heat exchanger of length 0.5m is to be used for this purpose, with a thin-walled inner tube having a diameter of 55mm.If water at 60^{0}C and 0.1kg/s is used to heat blood entering the exchanger and the heat flow rate. Take U_0=500W/m^2 K, c_p of blood=3.5kJ/kg K and c_p of water 4.183kJ/kg	solve	C

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	K.		
18	A flow of 0.1kg/s of exhaust gases at 700K from a gas turbine is used to preheat the incoming air, which is at the ambient temperature of 300K. It is desired to cool the exhaust to 400K and it is estimated that an overall heat coefficient of 30W/m^2K can be achieved in an appropriate exchanger.Determine the area required for a counter flow heat exchanger. Take the specific heat of exhaust gasses the same as for air, Which is 1000J/kgK.	solve	C
19	After a long time in service, a counter flow oil cooler is checked to ascertain if its performance has deteriorated due to fouling. In the heat transfer surface is 3.33m^2 and the design value of the overall heat transfer coefficient is 930W/m^2K, how much has it been reduced by fouling? c_p of oil as 2330J/kg K and c_p of water as 4174J/kgK.	remembering	C
20	A brass (k=111W/mK) condenser tube has a 30mm outer diameter and 2mm wall thickness. sea water enters the tube at 290K and the saturated low pressure steam condenses on the outer side of the tube. The inside and outside heat transfer coefficients are estimated to be 4000 and 8000W/m^2K, respectively and a fouling resistance of 10^{-4}(W/m^2K) on the water side is expected. Estimate the overall heat transfer coefficient based on inside area.	apply	B
PART – C (ANALYTICAL QUESTIONS)			
1	A chemical having specific heat of 3.3kJ/kg K flowing at the rate of 20000kg/h enters a parallel flow heat exchanger at 120^{0}C. The flow rate of cooling water is 50000kg/h with an inlet temperature of 20^{0}C.The heat transfer area is 10m^2 and the overall heat transfer coefficient is 1050W/m^2K. Find (i)the effectiveness of the heat exchanger, (ii)the outlet temperatures of water and chemical. Take for water c_p=4.186kJ/kgK	solve	6
2	In a double-pipe counter flow heat exchanger the inner tube has a diameter of 20mm and very little thickness. The inner diameter of the outer tube is 30mm.Water flows through the inner tube at a rate of 0.5kg/s and the oil flows through the shell at a rate of 0.8kg/s. Take the average temperatures of the water and the oil as 47^{0}C and 80^{0}C respectively and assume fully developed flow. Determine the overall heat transfer coefficient. Given:for water at 47^{0}C, ρ=0.637W/mK , v=0.59x$10^{-6}$$m^2$/s and Pr=3.79. For oil at 80^{0}C, ρ=852kg/m^3, k=0.138W/m K , nu =37.5x$10^{-6}$$m^2$/s and Pr=490.	Apply	7
3	The condenser of a large steam power plant is a shell-and-tube heat exchanger having a single shell and 30000tubes, with each tube making two passes. The tubes are thin-walled with 25mm diameter and steam condenses on the outside of the tubes with h_0=11kW/m^2K. The cooling water flowing through the tubes is 30000kg/s and the heat transfer rate is 2GW. Water enters at 20^{0}C while steam condenses at 50^{0}C. Find the length of the tubes in one pass. Properties of water at 27^{0}C are c_p=4.18kJ/kgK, μ =855x10^{-6}Ns/m^2 , k=0.613W/mK and Pr=5.83	evaluate	8
4	A double-pipe (shell-and-tube) heat exchanger is constructed of a stainless steel(k = 15.1 W/m · °C) inner tube of inner diameter *Di* _ 1.5 cm and outer diameter *Do* =1.9 cm and an outer shell of inner diameter 3.2 cm. The convection heat transfer coefficient is given to be *hi* =800 W/m^2 · °C on the inner surface of the tube and *ho* =1200 W/m^2 · °C on the outer surface. For a fouling factorof *Rf, i* = 0.0004 m^2 · °C/ W on the tube side and *Rf, o* = 0.0001 m^2 · °C/ W on the shell side, determine (*a*) the thermal resistance of the heat exchanger	solve	9

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	per unit length and (*b*) the overall heat transfer coefficients, *Ui* and *Uo* based on the inner and outer surface areas of the tube, respectively		
5	Steam in the condenser of a power plant is to be condensed at a temperature of30°C with cooling water from a nearby lake, which enters the tubes of the condenserat 14°C and leaves at 22°C. The surface area of the tubes is 45 m2, andthe overall heat transfer coefficient is 2100 W/m2 · °C. Determine the mass flowrate of the cooling water needed and the rate of condensation of the steam inthe condenser.	apply	10