HEAT TRANSFER

Subject code: ME603PC

Regulations: R16-JNTUH

Class: III Year B. Tech MECH II Sem

Department of Mechanical Engineering

BHARAT INSTITUTE OF ENGINEERING AND TECHNOLOGY

Ibrahimpatnam - 501 510, Hyderabad

HEAT TRANSFER (ME603PC)

COURSE PLANNER

I. OBJECTIVE AND RELEVANCE:

1. To learn the fundamental concepts in Heat transfer including objectives, scope and importance.
2. To identify the basic modes of Heat Transfer.
3. To evaluate the heat flow through a 1-D, SS system with no heat sources for rectangular, cylindrical and spherical geometries.
4. To recognize the equations and know the general solutions related fins.
5. To learn various methods of treating transient conduction which occurs in numerous engineering applications.
6. To perform engineering calculations that involve an energy balance and appropriate convection correlations.
7. To identify the essential physical features of the boiling and condensation processes and presents correlations suitable for the approximate engineering calculations.
8. To learn basic principles of thermal radiation and heat exchange between block & grey bodies.
9. To perform approximate heat exchanger calculations.

II. SCOPE OF COURSE:

1. To study fundamental concepts in Heat including objectives, scope and importance.
2. To Highlight the basic modes of Heat Transfer
3. To know the concepts and mathematical derivation of Steady and unsteady state one dimensional Heat transfer processes

III. **Pre-requisites**:

Thermodynamics & Fluid Mechanics: Fundamentals Conservation Laws (mass, momentum, energy), Boundary Layer Concept, Velocity Distribution, Laminar and Turbulent Flows, Friction Factor, Pressure Difference, Head Loss, etc.

IV. **Course Objectives**:

1	This course is designed to introduce a basic study of the phenomena of heat and mass transfer, to develop methodologies for solving a wide variety of practical engineering problems, and to provide useful information concerning the performance and design of particular systems and processes
2	A knowledge-based design problem requiring the formulations of solid conduction and fluid convection and the technique of numerical computation progressively elucidated in different chapters will be assigned and studied in detail
3	As well, to gain experience in designing experiments for thermal systems, the design, fabrication, and experimentation of a thin film heat flux gage will be attempted as part of laboratory requirements
4	Design flexibility into a plant layout to accommodate changes in product volume or product line

V. **COURSE OUTCOME**

Sl No	Description	Blooms

		Taxonomy levels
CO1	Upon successful completion of this course, the student will be able to understand the basic laws of heat transfer, account for the consequence of heat transfer in thermal analyses of engineering systems, and analyze problems involving steady state heat conduction in simple geometries.	Knowledge(L1),Understand(L2), Application(L3)
CO2	Develop solutions for transient heat conduction in simple geometries, obtain numerical solutions for conduction and radiation heat transfer problems, understand the fundamentals of convective heat transfer process.	Knowledge(L1),Understand(L2), Application(L3)
CO3	Evaluate heat transfer coefficients for natural convection, evaluate heat transfer coefficients for forced convection inside ducts	Knowledge(L1),Understand(L2), Application(L3)
CO4	Evaluate heat transfer coefficients for forced convection over exterior surfaces, analyze heat exchanger performance by using the method of log mean temperature difference	Knowledge(L1),Understand(L2), Application(L3)
CO5	Analyze heat exchanger performance by using the method of heat exchanger, effectiveness.	Knowledge(L1),Understand(L2), Application(L3)
CO6	Calculate radiation heat transfer between black body surfaces; calculate radiation heat exchange between gray body surfaces.	Knowledge(L1),Understand(L2), Application(L3)

VI. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes (PO)		Level	Proficiency assessed by
PO1	Engineering knowledge: Graduates will demonstrate the ability to use basic knowledge in mathematics, science and engineering and apply them to solve problems specific to mechanical engineering.	1	Assignments
PO2	Problem analysis: Graduates will demonstrate the ability to design and conduct experiments, interpret and analyze data, and report results.	2	Assignments
PO3	Design/development of solutions: Graduates will demonstrate the ability to design any mechanical system or thermal that meets desired specifications and requirements.	3	Assignments
PO4	Conduct investigations of complex problems: Graduates will demonstrate the ability to identify, formulate and solve mechanical engineering problems of a complex kind.	1	Assignments
PO5	Modern tool usage: Graduates will be familiar with	2	-

	applying software methods and modern computer tools to analyze mechanical engineering problems.		
PO6	The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	2	-
PO7	Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	2	-
PO8	Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	3	-
PO9	Individual and team work: Graduates will demonstrate the ability to function as a coherent unit in multidisciplinary design teams, and deliver results through collaborative research.	2	Projects
PO10	Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	2	Seminars
PO11	Project management and finance: Graduate will be able to design a system to meet desired needs within environmental, economic, political, ethical health and safety, manufacturability and management knowledge and techniques to estimate time, resources to complete project.	3	Projects
PO12	Life-long learning: Graduates should be capable of self-education and clearly understand the value of life-long learning.	1	Exams

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) - : None

I. JNTU SYLLABUS

UNIT – I

Introduction: Modes and mechanisms of heat transfer – Basic laws of heat transfer – General discussion about applications of heat transfer.

Conduction Heat Transfer: Fourier rate equation – General heat conduction equation in Cartesian, Cylindrical and Spherical coordinates – simplification and forms of the field equation – steady, unsteady, and periodic heat transfer – Initial and boundary conditions

One Dimensional Steady State Conduction Heat Transfer: Homogeneous slabs, hollow cylinders, and spheres- Composite systems– overall heat transfer coefficient – Electrical analogy – Critical radius of insulation

UNIT – II

One Dimensional Steady State Conduction Heat Transfer: Variable Thermal conductivity – systems with heat sources or Heat generation-Extended surface (fins) Heat Transfer – Long Fin, Fin with insulated tip and Short Fin, Application to error measurement of Temperature

One Dimensional Transient Conduction Heat Transfer: Systems with negligible internal resistance – Significance of Biot and Fourier Numbers –Infinite bodies- Chart solutions of transient conduction systems- Concept of Semi infinite body.

UNIT – III

Convective Heat Transfer: Classification of systems based on causation of flow, condition of flow, configuration of flow and medium of flow – Dimensional analysis as a tool for experimental investigation – Buckingham Π Theorem and method, application for developing semi – empirical non- dimensional correlation for convection heat transfer –Significance of non-dimensional numbers – Concepts of Continuity, Momentum and Energy Equations – Integral Method as approximate method -Application of Von Karman Integral Momentum Equation for flat plate with different velocity profiles.

Forced convection: External Flows: Concepts about hydrodynamic and thermal boundary layer and use of empirical correlations for convective heat transfer -Flat plates and Cylinders.

UNIT – IV

Internal Flows: Concepts about Hydrodynamic and Thermal Entry Lengths – Division of internal flow based on this –Use of empirical relations for Horizontal Pipe Flow and annulus flow.

Free Convection: Development of Hydrodynamic and thermal boundary layer along a vertical plate - Use of empirical relations for Vertical plates and pipes.

Heat Exchangers: Classification of heat exchangers – overall heat transfer Coefficient and fouling factor – Concepts of LMTD and NTU methods - Problems using LMTD and NTU methods.

UNIT - V

Heat Transfer with Phase Change:

Boiling: – Pool boiling – Regimes – Calculations on Nucleate boiling, Critical Heat flux and Film boiling.

Condensation: Film wise and drop wise condensation –Nusselt's Theory of Condensation on a vertical plate - Film condensation on vertical and horizontal cylinders using empirical correlations.

Radiation Heat Transfer: Emission characteristics and laws of black-body radiation – Irradiation – total and monochromatic quantities – laws of Planck, Wien, Kirchoff, Lambert, Stefan and Boltzmann– heat exchange between two black bodies – concepts of shape factor – Emissivity – heat exchange between grey bodies – radiation shields – electrical analogy for radiation network

TEXT BOOKS:

1. Heat and Mass Transfer – Dixit /Mc Graw Hill
2. Heat and Mass Transfer / Altamush Siddiqui/ Cengage

REFERENCE BOOKS:

1. Essential Heat Transfer - Christopher A Long / Pearson
2. Heat Transfer –Ghoshdastida / Oxford

IX. COURSE PLAN (WEEK – WISE)

Lecture No.	Week No.	TOPIC	Teaching Methodology	Reference	LEVELS
		UNIT - 1			
1.	1	Modes and mechanisms of heat transfer	Chalk & Talk	Book No. 1, 2,	L1,L2
2.		Basic laws of heat transfer	Chalk & Talk		L1,L2
3.		General discussion about applications of heat transfer	Chalk & Talk		L1,L2
4.		**Conduction Heat Transfer:** Fourier rate equation	Chalk & Talk		L1,L2
5.	2	General heat conduction equation in Cartesian	Chalk & Talk		L1,L2
6.		Cylindrical and Spherical coordinates	Chalk & Talk		L3
7.		Simplification and forms of the field equation	Chalk & Talk		L2
8.		periodic heat transfer	Chalk & Talk		
9.	3	Initial and boundary conditions	Chalk & Talk		L3
10.		**One Dimensional Steady State Conduction Heat Transfer:** Homogeneous slabs	Chalk & Talk		L3
11.		Hollow cylinders and spheres	Chalk & Talk		L3
12.		Composite systems	Chalk & Talk		L2
13.	4	Overall heat transfer coefficient	Chalk & Talk		L2
14.		Electrical analogy	Chalk & Talk		L2
15.		Critical radius of insulation	Chalk & Talk		L3
16.		Bridge class 1	Chalk & Talk		L3
		Mock Test 1			L3
		UNIT - 2			
17.	5	**One Dimensional Steady State Conduction Heat Transfer:** Variable Thermal conductivity	Chalk & Talk	Book No. 1, 2,	L1,L2
18.		Systems with heat sources or Heat generation	Chalk & Talk		L1,L2
19.		Extended surface (fins) Heat Transfer Long Fin	Chalk & Talk		L1,L2
20.		Fin with insulated tip and Short Fin	Chalk & Talk		L3

21.		Application to error measurement of Temperature	Chalk & Talk		L1,L2
22.	6	**One Dimensional Transient Conduction Heat Transfer:** Systems with negligible internal resistance	Chalk & Talk		L1,L2
23.		Significance of Biot and Fourier Numbers	Chalk & Talk		L1,L2
24.		Infinite bodies	Chalk & Talk		L1,L2
25.		Chart solutions of transient conduction systems	Chalk & Talk		L3
26.		Concept of Semi infinite body	Chalk & Talk		L3
		Tutorial / Bridge Class #2	Chalk & Talk		L3
UNIT – 3 Chalk & Talk					
27.	7	**Convective Heat Transfer:** Classification of systems based on causation of flow	Chalk & Talk	Book No. 1,2	L1,L2
28.		Condition of flow, configuration of flow and medium of flow	Chalk & Talk		L1,L2
29.		Dimensional analysis as a tool for experimental investigation	Chalk & Talk		L1,L2
30.		Buckingham Π Theorem and method	Chalk & Talk		L3
31.		Application for developing semi empirical non	Chalk & Talk		L3
32.	8	Dimensional correlation for convection heat transfer	Chalk & Talk		L3
33		Significance of non-dimensional numbers	Chalk & Talk		L3
34.		Concepts of Continuity Momentum and Energy Equations	Chalk & Talk		L3
35.		Integral Method as approximate method	Chalk & Talk		L3
		Tutorial / Bridge Class # 3	Chalk & Talk		L3
		I Mid Examinations (Week 9)			
		UNIT – 3 Contd.			
36.	10	Application of Von Karman Integral Momentum	Chalk & Talk	Book No. 1,2	L3
37.		Equation for flat plate with different velocity profiles.	Chalk & Talk		L3
38.		**Forced convection: External**	Chalk & Talk		L3

		Flows: Concepts about hydrodynamic and thermal boundary layer			
39.		Use of empirical correlations for convective heat transfer	Chalk & Talk		L3
40.		Revision	Chalk & Talk		
		Tutorial / Bridge Class # 4	Chalk & Talk		L3
		UNIT – 4			Chalk & Talk
41.	11	**Internal Flows:** Concepts about Hydrodynamic and Thermal Entry Lengths	Chalk & Talk	Book No. 1,2	L1,L2
42.		Division of internal flow	Chalk & Talk		L1,L2
43.		Division of internal flow	Chalk & Talk		L1,L2
44.		Use of empirical relations for Horizontal Pipe Flow and annulus flow	Chalk & Talk		L3
45.		Use of empirical relations for Horizontal Pipe Flow and annulus flow	Chalk & Talk		L3
46.	12	**Free Convection:** Development of Hydrodynamic and thermal boundary layer along a vertical plate	Chalk & Talk		L3
47.		Development of Hydrodynamic and thermal boundary layer along a vertical plate	Chalk & Talk		L3
48.		Use of empirical relations for Vertical plates and pipes	Chalk & Talk		L3
49.		Use of empirical relations for Vertical plates and pipes	Chalk & Talk		L3
		Tutorial / Bridge Class # 5	Chalk & Talk		L3
50.	13	**Heat Exchangers:** Classification of heat exchangers	Chalk & Talk		L1,L2
51.		Classification of heat exchangers	Chalk & Talk		L1,L2
52.		Overall heat transfer Coefficient	Chalk & Talk		L3
53.		Fouling factor	Chalk & Talk		L3
		Mock Test - II			L3
54.	14	Concepts of LMTD and NTU methods	Chalk & Talk		L1,L2
55.		Problems using LMTD and NTU methods	Chalk & Talk		L3

56.		Problems using LMTD and NTU methods	Chalk & Talk		L3
57.		Revision	Chalk & Talk		L3
		Tutorial / Bridge Class # 6	Chalk & Talk		L3
	UNIT – 5				Chalk & Talk
58.	15	**Boiling:** – Pool boiling	Chalk & Talk	Book No. 1,2	L1,L2
59.		Regimes – Calculations on Nucleate boiling	Chalk & Talk		L3
60.		Critical Heat flux	Chalk & Talk		L3
61.		Film boiling	Chalk & Talk		L3
62.	16	**Condensation:** Film wise and drop wise condensation	Chalk & Talk		L1,L2
63.		Nusselt's Theory of Condensation on a vertical plate	Chalk & Talk		L1,L2
64.		Film condensation on vertical and horizontal cylinders using empirical correlations	Chalk & Talk		L3
65.		**Radiation Heat Transfer:** Emission characteristics and laws of black-body radiation	Chalk & Talk		L3
66.		Irradiation – total and monochromatic quantities	Chalk & Talk		L1,L2
67.	17	laws of Planck,Wien, Kirchoff, Lambert, Stefan and Boltzmann	Chalk & Talk		L1,L2
68.		Heat exchange between two black bodies	Chalk & Talk		L3
69.		concepts of shape factor- Emissivity	Chalk & Talk		L3
70.		Heat exchange between grey bodies	Chalk & Talk		L3
71.		Electrical analogy for radiation network	Chalk & Talk		
72.		Radiation shields	Chalk & Talk		
		Tutorial / Bridge Class # 7	Chalk & Talk		L3
	II Mid Examinations (Week 18)				

Knowledge(L1) ,Understand(L2), Application(L3)

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

CO-PO MAPPING

CO's	Program Outcomes (PO's)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO.1 Able to Understand the basic modes of heat transfer	3	2	2	1	--	--	--	--	3	3	--	3
CO.2 Able to Compute one dimensional steady state heat transfer with and without heat generation	3	2	2	1	--	--	--	--	3	3	--	3
CO.3 Able to Understand and analyze heat transfer through extended surfaces	3	2	2	1	--	--	--	--	3	3	--	3
CO.4 Able to Understand one dimensional transient conduction heat transfer	3	3	2	1	--	--	--	--	3	3	--	3
CO.5 Able to Understand concepts of continuity, momentum and energy equations	3	3	2	1	--	--	--	--	3	3	--	3
CO.6 Able to Interpret and analyze forced and free convective heat transfer	3	3	2	1	--	--	--	--	3	3	--	3

CO-PSO MAPPING

CO's	Program Specific Outcomes (PSO's)		
	PSO1	PSO2	PSO3
CO.1 Able to Understand the basic modes of heat transfer	3	1	1
CO.2 Able to Compute one dimensional steady state heat transfer with and without heat generation	3	1	3

CO.3 Able to Understand and analyze heat transfer through extended surfaces	3	1	1
CO.4 Able to Understand one dimensional transient conduction heat transfer	3	1	1
CO.5 Able to Understand concepts of continuity, momentum and energy equations	3	1	1
CO.6 Able to Interpret and analyze forced and free convective heat transfer	3	1	1

X. QUESTION BANK (JNTUH)

UNIT I

Long Answer Questions:

Sl No	Question	Blooms Taxonomy Level	Course Outcome
1	State and explain Fourier's law of conduction. What is the significance of negative sign in the equation? A temperature difference of 845^0C is impressed across a fiberglass layer of 13cm thickness. The thermal conductivity of the fiberglass is 0.035 W/m K.Compute the heat transferred through the material per hour per unit area.	**L2**	**CO 1**
2	Derive general heat conduction equation in Cartesian co-ordinates.	**L2**	**CO 1**
3	Derive general heat conduction equation in Cylindrical co-ordinates.	**L2**	**CO 1**
4	Derive general heat conduction equation in Spherical co-ordinates.	**L2**	**CO 1**

Short Answer questions

Sl No	Question	Blooms Taxonomy Level	Course Outcome
1	Identify the different modes of heat transfer the following systems/ operations. (a) Steam raising in a steam boiler. (b) Air / water cooling of an I.C. engi cylinder.	**L1**	CO1

	(c) Heat loss from a thermos flask. (d) Heating of water in a bucket with a immersion heater. (e) Heat transfer from a room heater. (f) Heat transfer in a refrigerator cabin.		
2	With relevant examples, explain the mechanisms of conduction, convection and radiation heat transfer.	**L2**	CO1
3	Explain clearly the basic laws of Heat transfer.	**L2**	CO1

Unit II

Long Answer Questions

Sl No	Question	Blooms Taxonomy Level	Course Outcome
1	Determine the steady heat transfer per unit area through a 3.8 cm thick homogeneous slab with its two faces maintained at uniform temperatures of 35^0C and 25^0C. The thermal conductivity of wall material is 1.9 X 10^{-4} kW/m-K.	**L2,L3**	**CO 1 CO 2**
2	Derive an expression for temperature distribution in a slab when T1 and T2 are its surface temperatures. Assume that the thermal conductivity of the slab varies with temperature $k = k_0 (1+\alpha T)$	**L2,L3**	**CO 1 CO 2**
3	A 0.5cm thick and 4cm long fin has its base on a plane plate which is maintained at 110^0C. The ambient air temperature is 20^0C. The conductivity of the fin material is 60 W/m-K and the heat transfer coefficient h= 150 W/m2K. Determine. Assume that the tip of the fin is insulated. i. Temperature at the end of the fin ii. Temperature at the middle of the fin	**L2,L3**	**CO 1 CO 2**
4	Heat is generated at a constant rate of 4X108W/m3 in a copper rod (3.86 W/mK) of radius 5 mm. The rod is cooled by convection from its cylindrical surface into an ambient at 300C with a heat transfer coefficient of 2000 W/m2K. Determine the surface temperature of the rod.	**L2,L3**	**CO 1 CO 2**

5	During a heat treatment process a spherical object of 5 cm diameter is cooled in one minute in an oil bath from 150C to 60C. If a cube made of the same material with a side of 50 mm is to be cooled between the same temperature limits, calculate the time required. Assume negligible internal thermal resistance.	**L2,L3**	**CO 1 CO 2**

Short Answer Questions

Sl No	Question	Blooms Taxonomy Level	Course Outcome
1	Explain clearly the analogy between heat and electricity.	**L1**	CO1
2	What do you under- stand by the term over all heat transfer coefficient?	**L1**	CO1
3	What is meant by a lumped capacity?	**L1**	CO1
4	What are the physical assumptions necessary for a lumped- capacity unsteady-state analysis to apply?	**L1**	CO1
5	What is critical thickness of insulator on a small diameter wire or pipe.	**L1**	CO1

Unit III
Long Answer Questions

Sl No	Question	Blooms Taxonomy Level	Course Outcome
1	Show by dimensional analysis that data for forced convection may be correlated by an equation of the form Nu=f(Re,Pr).	**L2,L3**	**CO 1 CO 3**
2	Explain the Reynolds's Analogy in forced convection. (b) Water flows inside a smooth tube at a mean flow velocity of 3.0 m/s. The tube diameter is 25mm and constant heat flux condition is maintained at the tube wall such that the tube temperature is always 200C above the water temperature. The water enters the tube at 300C and	**L2,L3**	**CO 1 CO 3**

	leaves at 500C. Calculate the tube length necessary to accomplish the indicated heating		
3	A pipe with a diameter of 2 cm is kept at a surface temperature of 40 ^{0}C. Find the heat transfer rate per m length of this pipe if it is i. Placed in an air flow in which the temperature is 50 ^{0}C and ii. placed in a tank of water kept a temperature of 30 ^{0}C. The heat transfer coefficient in these two situations, which involve A. forced convection in air and B. free convection in water, are estimated to be 20 W/m^2 K and 70 W/m^2 K respectively.	**L2,L3**	**CO 1 CO 3**
4	A thin at plate has been placed longitudinally in a steam of air at 200C and while flows with undisturbed velocity of 7.5 m/s. The surface of plate is maintained at a uniform temperature of 120^{0}C. i. calculate the heat transfer coefficient 0.8m from the leading edge of the plate, ii. Also calculate the rate of heat transfer from one side of the plate to the air over the first 0.8 m length. Assume unit width of the plate.	**L2,L3**	**CO 1 CO 3**
5	How are the local and average convection coefficients for a flow past a flat plate are related? Derive the relationship.	**L2,L3**	**CO 1 CO 3**

Short Answer Questions

Sl No	Question	Blooms Taxonomy Level	Course Outcome
1	What is the significance of dimensional analysis.	**L1**	CO1
2	What is meant by Reynolds's Analogy in forced convection.	**L1**	CO1
3	Briefly explain the Buckingham's π-Theorem for dimensional analysis.	**L1**	CO1
4	What are repeating variables and how are they selected for dimensional analysis.	**L1**	CO1
5	What do you understand by the hydrodynamics and thermal boundary layers. Illustrate with reference to flow over a at heated plate.	**L1**	CO1

Unit IV

Long Answer Questions

Sl No	Question	Blooms Taxonomy Level	Course Outcome
1	(a) Deduce average heat transfer co-efficient equation in film condensation on a Vertical at plate using Nusselt's theory. (b) A heated brass plate at 160^0C is submerged horizontally in water at a pressure corresponding to a saturation temperature of 120^0C. What is the heat transfer per unit area? Calculate also the heat transfer coefficient in boiling.	**L2,L3**	**CO 1 CO 3**
2	The condenser of a steam power plant operates at a pressure of 7.38 kPa. Steam at this pressure condenses on the outer surfaces of horizontal pipes through which cooling water circulates. The outer diameter of the pipes is 2 cm, and the outer surfaces of the pipes are maintained at 30 ^{0}C. Determine (a) the rate of heat transfer to the cooling water circulating in the pipes and (b) the rate of condensation of steam per unit length of a horizontal pipe.	**L2,L3**	**CO 1 CO 3**
3	Explain the conditions under which drop wise condensation can take place. Why does the rate of heat transfer in drop-wise condensation many times larger than in film-wise condensation? (b) A steam condenser consists of 100 tubes, each 1.27mm in diameter are arranged in a square array. If the tubes are exposed to dry steam at atmospheric pressure and the tube surface temperature is maintained at 98^oC, what is the rate at which steam is condensed per unit length of the tubes?	**L2,L3**	**CO 1 CO 3**
4	Show that the direct heat exchange area between a disc of radius `r' and a sphere of radius `R', whose center is on the normal through the center of the disc separated by a center to center distance `H' is 2 π R2 [1 - {H / √(H2 + r2)g}].	**L2,L3**	**CO 1 CO 3**
5	(a) Explain the utility of radiation shields. (b) Two large parallel planes having emissivities 0.3 and 0.5 are maintained at temperatures of 900 0C and 4000C respectively. A radiation shield having an	**L2,L3**	**CO 1 CO 3**

	emissivity of 0.05 is placed between the two planes. Estimate: i. Heat exchange per m2 of area if the shield were not present (c) ii. Temperature of the shield, and (d) iii. Heat exchange per m2 area when the shield is present.		
6	Fused quartz transmits 90% of the incident thermal radiation between 0.2 and 4 μm. suppose a certain heat source is viewed through the quartz window, what heat flux in Watts will be transmitted through the material from black body radiation sources at: i. 800 ^{0}C ii. 550 ^{0}C	**L2,L3**	**CO 1 CO 3**
7	(a) State and prove reciprocity theorem as applied to radiation shape factors. (b) Two concentric cylinders having diameters of 10cm and 20 cm have a length of 20cm. Calculate the shape factor between the open ends of the cylinders.	**L2,L3**	**CO 1 CO 3**

Short Answer Questions

Sl No	Question	Blooms Taxonomy Level	Course Outcome
1	Why are heat transfer rates high for a phase change process?	**L1**	CO1
2	Differentiate between pool boiling and film boiling.	**L1**	CO1
3	List various regimes of pool boiling and show it with neat sketch.	**L1**	CO1
4	Write short notes on nucleate boiling.	**L1**	CO1
5	What are radiation shape factors? Why are they used?	**L1**	CO1
6	Define the terms i. Absorptivity ii. Reflectivity and iii. Transmissivity	**L1**	CO1
7	Differentiate between specular and diffused radiation.	**L1**	CO1
8	State Stefan Boltzman law and Planck;s law of radiation.	**L1**	CO1

Unit V

Long answer questions

Sl No	Question	Blooms Taxonomy Level	Course Outcome
1	(a) How does the log mean temperature difference for a heat exchanger differ from the arithmetic mean temperature difference? For specified inlet and outlet temperatures, which one of these two quantities is larger? (b) A shell-and-tube heat exchanger has condensing steam at 100 ^{0}C in the shell side with one shell pass. Two tube passes are used with air in the tubes entering at 10 ^{0}C. The total surface area of the exchangers is 30 m2 and the overall heat-transfer coefficient may be taken as 150 W/m2.K. If the effectiveness of the exchanger is 85 percent, what is the total heat transfer rate?	**L2,L3**	**CO 1 CO 3**
2	Hot oil is to be cooled by water in a one shell pass and eight tube passes heat exchanger. The tubes are thin walled and made of copper with an internal diameter of 14 mm. The length of each tube pass is 5 m and U_0 = 310 W/m2K. Water flows through the tubes at a rate of 0.2 kg/s and the oil through the shell at a rate of 0.3 kg/s. The water and the oil enter at temperatures of 20^{0}C and 150^{0}C respectively. Determine the rate of heat transfer and the exit temperatures of the water and the oil	**L2,L3**	**CO 1 CO 3**
3	a) In a gas to liquid heat exchanger, why are fins provided on gas side? Explain. (b) Determine the overall heat transfer coefficient based on the outer area of a 3.81 cm O.D. and 3.175 cm I.D. brass tube (k = 103.8 W/m.K) if the heat transfer coefficients for flow inside and outside the tube are 2270 and 2840 W/m2K respectively and the unit fouling resistances at inside and outside are Rfi = Rfo = 0.0088m2 K/W	**L2,L3**	**CO 1 CO 3**
4	(a) Derive an expression for logarithmic mean temperature difference for the case of counter flow	**L2,L3**	**CO 1 CO 3**

	of heat exchanger. (b) A hot fluid enters a heat exchanger at a temperature of 200 0C at a flow rate of 2.8 kg/s (sp. heat 2.0 kJ/kg-K) it is cooled by another fluid with a mass flow rate of 0.7kg/sec (Specific .heat 0.4 kJ/kg-K). The overall heat transfer coefficient based on outside area of 20m2 is 250W/m2-K. Calculate the exit temperature of hot fluid when fluid when fluids are in parallel flow.		
5	A one shell pass, two tube pass heat exchanger has a total surface area of 5 m2 and its overall heat transfer coefficient based on that area is found to be 1400 W/m2K. If 4500 kg/h of water enters the shell side at 315^{o}C while 9000 kg/h of water enters the tube side at 40^{0}C, find the outlet temperatures using (a) The correction factor LMTD method and (b) Effectiveness-NTU method. Take c_p for both fluid streams as 4.187 kJ/kg	**L2,L3**	**CO 1 CO 3**

Short answer questions

Sl No	Question	Blooms Taxonomy Level	Course Outcome
1	Differentiate between contact and in-direct contact type heat exchanger.	**L1**	CO1
2	Q.2 Briefly explain the regenerative heat exchanger.	**L1**	CO1
3	Q.3 Write short notes on recuperative heat exchanger	**L1**	CO1
4	Q.4 Write short notes on LMTD and AMTD	**L1**	CO1
5	Q.5 Differentiate between counter flow and parallel flow heat exchangers.	**L1**	CO1

Knowledge(L1) ,Understand(L2), Application(L3)

<u>OBJECTIVE QUESTIONS</u>

<u>i)JNTUH:</u>

UNIT—I

1. Heat transfer takes place by the process [ ]
a) Conduction b) Convection c) Radiation d) all of the above
2. The basic law of heat conduction is called [ ]

a) Newton's law of cooling b) Fourier's law c) Kirchhoff's law d) Stefan's law
3. The thermal conductivity in MKS units is expressed as [ ]
a) kcal/hr m oC b) kcal/hr m^2 oC c) kcal/moC d) kcal/hr m^3 oC
4. The process of heat transfer, from one particle of the body to another without actual motion of the particles, is called__________

UNIT-II

1. If the rate of heat transfer is constant, it is known as [ ]
a) Steady –state heat transfer b) Unsteady –state heat transfer
c) Uniform heat transfer d) Non-uniform heat transfer
2. The co-efficient of thermal conductivity is defined as the heat flow per unit time [ ]
a) Through unit thickness
b) When temperature difference of unity is maintained between opposite faces
c) When temperature gradient is unity
d) Across unit area when temperature gradient is unity
3 For steady flow and constant value of conductivity, the temperature distribution for a plane wall is [ ]
a) Parabolic b) Linear c) Logarithmic function of radii d) Cubic
4.. Critical radius of insulation for a hollow cylinder is equal to_____________
5. A continuum is said to be homogeneous if its conductivity does not vary from________
6. Thermal conductivity of solid metals ___________with rise in temperature

7. Biot number is the ratio of conductive resistance to _______ resistance. [ ]
a) Convective b) Conduction c) Radiation d) None of these
8. Lumped system, temperature of a body is __________and only varies with_________.
9. The Fourier number can be used to solve ________state conduction problems

UNIT---III

1. Reynolds number is the ratio of [ ]
a) Energy transferred by convection to that by conduction
b) Kinematic viscosity to thermal diffusivity
c) Inertia force to viscous force d) None of the above
2. The thickness of thermal and hydrodynamic boundary layer is equal if prandtl number is [ ]
a) Equal to one b) Greater than one c) Less than one d) Equal to Nusselt number
3. The ratio the thickness of thermal boundary layer to the thickness of hydrodynamic boundary layer is equal to (Prandtl number)n, where *n* is equal to [ ]
a) -1/3 b) -2/3 c) 1 d) -1
4.. The rate of heat transfer from solid surface to a fluid is obtained from________
5. The heat transfer, from one practical of a fluid to another by actual motion of the fluid is known as___________
6. For a forced convection, Nusselt number is a function of ___________
7. Heat flux to the boundary is____________
8. Free convection depends on [ ]
a) Density b) coefficient of viscosity c) gravitational force d) all of these

9. The thickness of thermal and hydrodynamic boundary layer is equal if Prandtl number is ______ [ ]
a) Equal to one b) greater than one c) less than one d) equal to Nusselt number
10. The ratio of the thickness thermal boundary layer to the thickness of hydrodynamic boundary layer is equal to (Prandtl number)n,where n is equal to__________
11. In free convection heat transfer transition from laminar to turbulent flow is governed by the critical value of the_____________________
12. The three modes of heat transfer are conduction, radiation and
13. Nusselt number (*N*N)is given by ______________

UNIT---IV

1. In pool boiling the fluid body is __________ and any motion of the fluid is due to the natural convection current. [ ]
a) Stationery b) moving c) transition d) none of these
2. The region beyond the point 'D' indicates film boiling.'D' is the point when heat flux is______ [ ]
a) Maximum b) minimum c) both a &b d) none of these
3. The emissivity for a black body is [ ]
a) 0 b) 0.5 c) 0.75 d) 1
4. The unit of Stefan-Boltzmann constant is [ ]
a) Watt/m K b) Watt/m2 K2 c) Watt/m2 k4 d) Watt/m K2
5. The emissivity of polished silver body is _____________as compard to black body.
6. The value of the wave length for maximum emissive power is given by____________
7. The expression Q=*ρAT*4 is called _____________
8. The Poisson's equation the general conduction heat transfer applies to the case
(a) Steady state heat conduction with heat generation.
(b) Steady state heat conduction without heat generation.
(c) Unsteady state heat conduction without heat generation.
(d) Unsteady state heat conduction with heat generation.
9.A plane slab of 100 mm thickness generates heat. It is observed that the temperature drop between the centre and its surface to be 50°C. If the thickness is increased to 20cm the temperature difference will be(a) 100°C (b) 200°C(c) 400°C(d) 600°C
10..Three fins of equal length and diameter but made of aluminium, brass and castiron are heated to200°C at one end. If the fins dissipate heat to the surrounding air at 25°
C the temperature at the free end will be least in case of
(a) aluminium fin (b) brass fin
(c) cast-iron fin (d) each fin will have the same temperature at the free end
11.Stefan-Boltzmann constant is 5.67×108W/m2.K4
(a) 1026 kW/m2 (b) 10.26 kW/m2 (c) 102.6 kW/m2 (d) 1.026 kW/m2
12.Uniform heat generation takes place in a symmetric slab so that heat flows towards both sides in contact with fluid. The zero-gradient boundary condition occurs at
(a) left wall of slab (b) right wall of slab (c) centerline of slab (d) nowhere in slab

UNIT---V

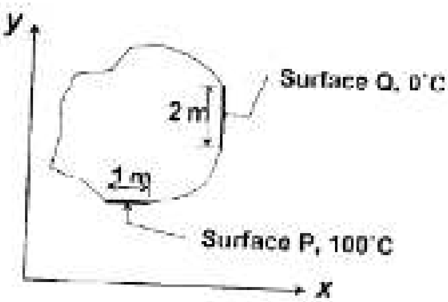
1. In parallel flow heat exchanger both the hot and cold fluids enter the end and move in the _____direction. [ ]
a) Opposite b) Reverse c) same d) none of these
2. In counter-current flow heat exchanger, the logarithmic temperature difference between the fluids is _________as compared to parallel flow heat exchanger. [ ]
a) Same b) less c) greater d) none of these
3. The automobile radiator is a heat exchanger of [ ]
a) Parallel flow type b) counter flow type c) cross flow type d) regenerator type
4. In a heat exchanger with one fluid evaporating or condensing,the surface area required is least in [ ]
a) Parallel flow b) counter flow c) cross flow d) all of these
5. The counter –current flow heat exchanger can transfer ____________heat than parallel flow heat exchanger.
6. Fouling factor is used ____________
7. Film coefficient is defined as the ratio of________________

ii GATE QUESTIONS:

1. For a given heat flow and for the same thickness, the temperature drop across the material will be maximum for
(a) Copper (b) Steel (c) Glass-wool (d) Refractory brick

2. Steady two-dimensional heat conduction takes place in the body shown in the figure below. The normal temperature gradients over surfaces P and Q can be considered to be uniform. The temperature gradient ∂T/∂x at surface Q is equal to 10 k/m. Surfaces P and Q are maintained at constant temperatures as shown in the figure, while the remaining part of the boundary is insulated. The body has a constant thermal conductivity of 0.1 W/m.K. The values of ∂T/∂x and ∂T/∂y at surface P are:

(a) $\frac{\partial T}{\partial x} = 20K/m, \frac{\partial T}{\partial y} = 0K/m$
(b) $\frac{\partial T}{\partial x} = 0K/m, \frac{\partial T}{\partial y} = 10K/m$
(c) $\frac{\partial T}{\partial x} = 10K/m, \frac{\partial T}{\partial y} = 10K/m$
(d) $\frac{\partial T}{\partial x} = 0K/m, \frac{\partial T}{\partial y} = 20K/m$



[GATE-2008]

3. A steel ball of mass 1kg and specific heat 0.4 kJ/kg is at a temperature of 60°C. It is dropped into 1kg water at 20°C. The final steady state temperature of water is:
(a) 23.5°C (b) 300°C (c) 35°C (d) 40°C
4. In descending order of magnitude, the thermal conductivity of
a. Pure iron, b. Liquid water, c. Saturated water vapour, and
d. Pure aluminium can be arranged as
(a) a b c d (b) b c a d (c) d a b c (d) d c b a

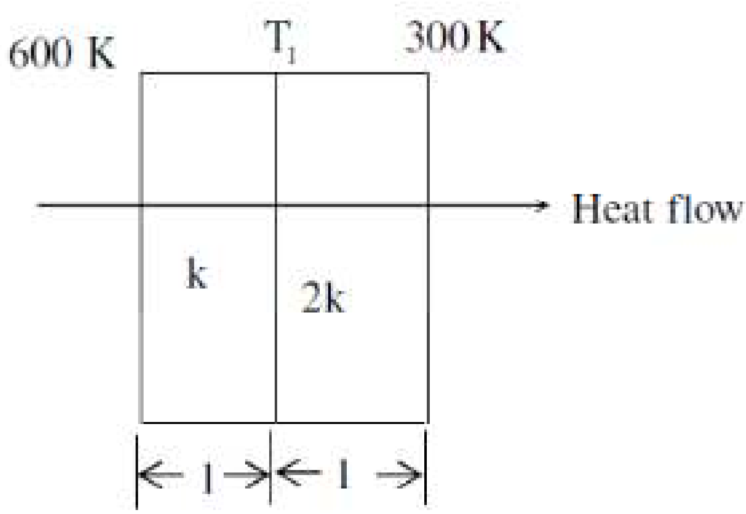
5. A 10mm diameter electrical conductor is covered by an insulation of 2mm thickness. The conductivity of the insulation is 0.08 W/mK and the convection coefficient at the insulation surface is $10 W/m^2K$. Addition of further insulation of same material will

(a) increase heat loss continuously
(b) decrease heat loss continuously
(c) increase heat loss to a maximum and then decrease heat loss
(d) decrease heat loss to a maximum and then increase heat loss

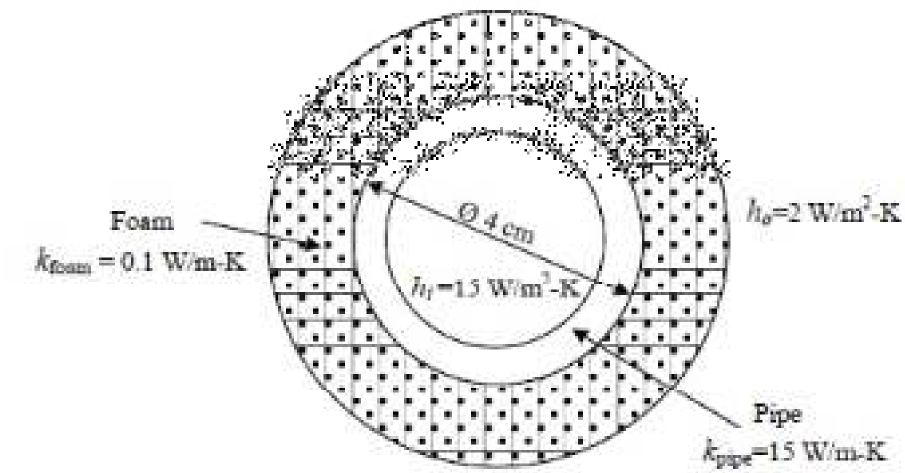
6. Consider one-dimensional steady state heat condu ction, without heat generation, in a plane wall; with boundary conditions as shown in the figure below. The conductivity of the wall is given by dT / dx will
(A) Remain constant (B) Be zero (C) Increase (D) Decrease

7. A brick wall (k=0.9W/mK) of thickness 0.18m separates warm air in a room from the cold ambient air. On a particular winter day, the outside air temperature is -5°C and the rooms need to be the maintained at 27°C. the heat transfer coefficient associated with the outside air is 20 W/m^2K. Neglecting the convective resistance of the air inside the room, the heat loss in W/m^2 is
(a) 88 (b) 110 (c) 128 (d) 160

8.Heat transfer through a composite wall is shown in figure. Both the sections of the wall have equal thickness (l). The conductivity of one section is k and that of the other is 2k. The left face of the wall is at 600 K and the right face is at 300 K. The interface temperature Ti (in K) of the composite wall is _______



9. If a foam insulation is added to a 4cm diameter pipe as shown in the figure, the critical radius of insulation in cm is___________



10. A pipe of 25mm outer diameter carries steam. The heat transfer coefficient between the cylinder and surroundings is 2 5W/m K . It is proposed to reduce the heat loss from the pipe by adding insulation having a thermal conductivity of 0.05W/mK. Which one of the following statements is TRUE?

(A) The outer radius of the pipe is equal to the critical radius
(B) The outer radius of the pipe is less than the critical radius
(C) Adding the insulation will reduce the heat loss
(D) Adding the insulation will increase the heat loss

11. Consider a long cylindrical tube of inner and outer radii, r_i and r_o, respectively, length, L and thermal conductivity, k. Its inner and outer surfaces are maintained at T_i and T_0, respectively ($T_i > T_O$). Assuming one-dimensional steady state heat conduction in the radial direction, the thermal resistance in the wall of the tube is

(A) $\frac{1}{2\pi kL}\ln\left(\frac{r_i}{r_o}\right)$ (B) $\frac{1}{2\pi r_i k}$ (C) $\frac{1}{2\pi r_i k}\ln\left(\frac{r_o}{r_i}\right)$ (D) $\frac{1}{4\pi r_i k}\ln\left(\frac{r_o}{r_i}\right)$

12. A cylindrical Uranium fuel rod of radius 5mm in a nuclear reactor is generating heat at the rate of $4X10^7$ W/m^3. The rod is cooled by a liquid (convective heat transfer coefficient 1000W/m^{2}K) at 25ºC. At the steady state, the surface temperature (in K) of the rod is ______

(a) 308 (b) 398 (c) 418 (d) 448

13. A fin has 5mm diameter and 100mm length. The thermal conductivity of fin material is 400Wm−1K−1. One end of the fin is maintained at 130ºC and its remaining surface is exposed to ambient air at 30ºC. if the convective heat transfer coefficient is 40Wm-2K-1, the heat loss (in W) from the fin is

(A) 0.08 (B) 5.0 (C) 7.0 (D) 7.8

14. Biot number signifies the ratio of

(A) Convective resistance in the fluid to conductive resistance in the sold
(B) Conductive resistance in the solid to convective resistance in the fluid
(C) Inertia force to viscous force in the fluid
(D) Buoyancy force to viscous force in the fluid

15. The ratios of the laminar hydrodynamic boundary layer thickness to thermal boundary layer thickness of flows of two fluids P and Q on a flat plate are12and2 respectively. The Reynolds number based on the plate length for both the flows is 4, 10 The Prandtl and Nusselt numbers for P are18and 35 respectively. The Prandtl and Nusselt numbers for Q are respectively

(A) 8 and 140 (B) 8 and 70 (C) 4 and 70 (D) 4 and 35

16. Match the following

P:Compressible flow U: Reynolds number Q: Free surface flow V: Nusselt number

R: Boundary layer flow W: Weber number S: Pipe flow X: Froude number

T: Heat convection Y: Mach number Z: Skin friction coefficient

(A) P-U; Q-X; R-V; S-Z; T-W (B) P-W; Q-X; R-Z; S-U; T-V

(C) P-Y; Q-W; R-Z; S-U; T-X (D) P-Y; Q-W; R-Z; S-U; T-V

17. A coolant fluid at 30°C flows over a heated flat plate maintained at a constanttemperature of 100°C. The boundary layer temperature distribution at a given location on the plate may be approximated as T □□30 □□70exp □−y□□where y (in m)is the distance normal to the plate and T is in °C. If thermal conductivity of the fluid is 1.0W/mK, the local convective heattransfer coefficient (in W/m2K) at that location will be

(A) 0.2 (B) 1 (C) 5 (D) 10

18. The total emissive power of a surface is $500W/m^2$ at a temperature T_1 and 1200 W/m^2 at a temperature T_2, Where the temperatures are in Kelvin. Assuming the emissivity of the surface to be constant, the ratios of temperatures T_1/ T_2

(a) 0.308 (b) 0.416 (c) 0.803 (d) 0.874

19. Radiative heat transfer is intended between the inner surfaces of two very large isothermal parallel metal plates. While the upper plate (designated as plate 1) is a black surface and is the warmer one being maintained at 727ºC, the lower plate (plate) is a diffuse and gray surface with an emissivity of 0.7 and is keptat 227ºC. Assume that the surfaces aresufficiently large to form a two-surfaceenclosure and steady state conditions to exist. Stefan Boltzmann constant is given as $5.67×10\text{-}8W/m^2K$

(a) The irradiation (in kW/m2) for the upper plate (plate 1) is

(A) 2.5 (B) 3.6 (C) 17.0 (D) 19.5

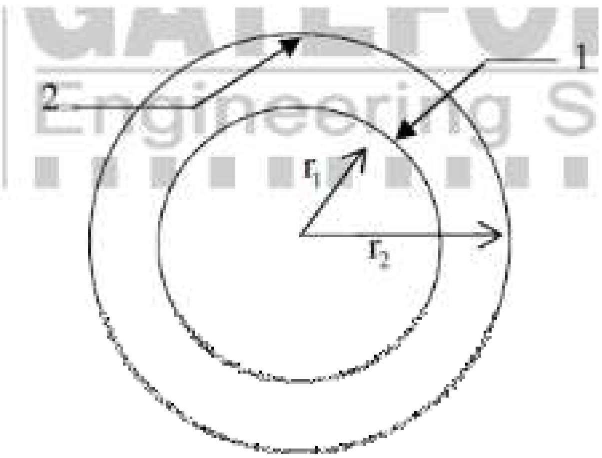
(b) If plate 1 is also a diffuse and gray surface with an emissivity value of 0.8, the net radiation heat exchange (in kW/m2) between plate 1 and plate 2 is

(A) 17.0 (B) 19.0 (C) 23.0 (D) 31.7

20. Two large diffuse gray parallel plates, separated by a small distance, have surface temperatures of 400 K and 300 K. If the emissivities of the surfaces are 0.8 and the Stefan-Boltzmann constant is 5.67 10 W / m K −, the net radiation heat exchange rate in 2kW / mbetween the two plates is

(A) 0.66 (B) 0.79 (C) 0.99 (D) 3.9

21. A solid sphere of radius r1 = 20 mm is placed concentrically inside a hollow sphere of radius r2 = 30 mm as shown in the figure.



The view factor F21 for radiation heat transfer is

(A) $\frac{2}{3}$ (B) $\frac{4}{9}$ (C) $\frac{8}{27}$ (D) $\frac{9}{4}$

22. A balanced counter flow heat exchanger has a surface area of 20 m^2 and overall heat transfer coefficient of 20W/m^2K. Air (c_p=1000J/Kg-K) entering at 0.4Kg/s and 280K is to be pre heated by the air leaving the system at the 0.4Kg/s and 300K. The outlet temperature (K) of pre heated air is____

(a) 290 (b) 300 (c) 320 (d) 350

23. In a parallel flow heat exchanger operating under steady state, the heat capacity rates (product of specific heat at constant pressure and mass flow rate) of the hot and cold fluid are equal. The hot fluid, flowing at 1kg/s with Cp = 4kJ/kgK, enters the heat exchanger at 102°C while the cold fluid has an inlet temperature of 15°C. The overall heat transfer coefficient for the heat exchanger is estimated to be 1kW/m2K and the corresponding heat transfer surface area is 5m2. Neglect heat transfer between the heat exchanger and the ambient. The heat exchangeris characterized by the following relation: −□exp □−2NTU□□.

The exit temperature (in °C) for the cold fluid is

(A) 45 (B)55 (C) 65 (D) 75

24. In a heat exchanger, it is observed that $\Delta T_1 = \Delta T_2$, where ΔT_1 is the temperature difference between the two single phase fluid streams at one end and ΔT_2 is the temperature difference at the other end. This heat exchanger is

(A) a condenser (B) an evaporator

(C) a counter flow heat exchanger (D) a parallel flow heat exchanger

25.In a concentric counter flow heat exchanger, water flows through the inner tube at 25OC and leaves at 42OC. The engine oil enters at 100°C and flows in the annular flow passage. The exit temperature of the engine oil is 50OC. Mass flow rate of water and the engine oil are 1.5 kg/s and 1 kg/s, respectively. The specific heat of water and oil are 4178 J/kg.K and 2130 J/kg.K, respectively. The effectiveness of this heat exchanger is _______

26.A double-pipe counter-flow heat exchanger transfers heat between two water streams. Tube side water at 19 liter/s is heated from $10^{O}C$ to $38^{O}C$. Shell side water at 25 liter/s is entering at $46^{O}C$. Assume constant properties of water, density is 1000 kg/m3 and specific heat is 4186 J/kg K. The LMTD (in ^{O}C) is ________

iii) <u>IES QUESTIONS:</u>

1. A copper block and an air mass block having similar dimensions are subjected to symmetrical heat transfer from one face of each block. The other face of the block will be reaching to the same temperature at a rate:
(a) Faster in air block (b) Faster in copper block (c) Equal in air as well as copper block (d) Cannot be predicted with the given information
2. Consider the following statements:
The Fourier heat conduction equation dT Q kA dx = − presumes
1. Steady-state conditions
2. Constant value of thermal conductivity.
3. Uniform temperatures at the wall surfaces
4. One-dimensional heat flow.
Of these statements:
(a) 1, 2 and 3 are correct (b) 1, 2 and 4 are correct (c) 2, 3 and 4 are correct (d) 1, 3 and 4 are correct
3. A plane wall is 25 cm thick with an area of 1 m^2, and has a thermal conductivity of 0.5 W/mK. If a temperature difference of 60°C is imposed across it, what is the heat flow?
(a) 120W (b) 140W (c) 160W (d) 180W
4. A plane wall is 20cm thick with an area perpendicular to heat flow of 1m2 and has a thermal conductivity of 0.5 W/mK A temperature difference of $100^{O}C$ is imposed across it. The rate of heat flow is
(A) 0.10kW (B) 0.15kW (C) 0.20kW (D) 0.25kW
5. Determine the heat transfer through a plane of length 4m, height 3 m and thickness 0.2m. The temperatures of inner and outer surfaces are $150^{O}C$ and $90^{O}C$ respectively. Thermal conductivity of the wall is 0.5 W/mK.
(A) 1800W (B) 2000W (C) 2200W (D) 2400W
6. In an equation of Fourier law of heat conduction, heat flow through a body per unit time is Q= –kA dT/dx the negative sign of k in this equation is to take care of
(A) Decreasing temperature along the direction of increasing thickness
(B) Increasing temperature along the direction of increasing thickness
(C) Constant temperature along the direction with constant thickness
(D) All of the above
7. A flat wall with a thermal conductivity of 0.2 kW/mK has its inner and outer surface temperatures 600 oC and 200°C respectively. If the heat flux through the wall is 200 kW/m2 , what is the thickness of the wall?
(A) 10 cm (B) 20 cm (C) 30 cm (D) 40 cm

8. An insulating material with a thermal conductivity, k = 0.12 W/mK is used for a pipe carrying steam. The local coefficient of heat transfer (h) to the surrounding is 2 4W m K. in order to

provide effective insulation, the minimum outer diameter of the pipe should be (A) 45mm (B) 60mm (C) 75mm (D) 90mm

9. A large concrete slab 1 m thick has one dimensional temperature distribution:

$T = 4 - 10x + 20x^2 + 10x^3$ Where T is temperature and x is distance from one face towards other face of wall. If the slab material has thermal diffusivity of 2×10^{-3} m^2/hr, what is the rate of change of temperature at the other face of the wall?

(a) 0.1°C/h (b) 0.2°C/h (c) 0.3°C/h (d) 0.4°C/h

23. A fin will be more effective when Biot number is

(A) Greater than 1 (B) Equal to 1 (C) Between 1 3 and 4 4 (D) Less than 1

10. Consider the following statements: An increase in pin fin effectiveness is caused by high value of (1) Convective coefficient (2) Thermal conductivity (3) Sectional area (4) Circumference Which of the above statements are correct? (A) 1 and 3 (B) 1 and 4 (C) 2 and 3 (D) 2 and 4

11. There is a uniform distributed source of heat present in a plane wall whose one side (x = 0) is insulated and other side (x = L) is exposed to ambient temperature) ∞T(, with heat transfer coefficient (h). Assuming constant thermal conductivity (k), steady state and one dimensional conduction, the temperature of the wall is maximum at x equal to (A) 0 (B) L (C) L/2 (D) L/4

12. Thermal diffusivity of a substance is:

(a) Inversely proportional to thermal conductivity

(b) Directly proportional to thermal conductivity

(c) Directly proportional to the square of thermal conductivity

(d) Inversely proportional to the square of thermal conductivity

13. Which one of the following expresses the thermal diffusivity of a substance in terms of thermal conductivity (k), mass density (ρ) and specific heat (c)?

(a) $k^2 \rho c$ (b) $1/\rho k c$ (c) $k/\rho c$ (d) $\rho c/k^2$

14. The conduction heat diffuses in a material when the material has 1. High thermal conductivity 2. Low density 3. High specific heat 4. High viscosity Which of the above are correct?

(A) 1 and 2 (B) 2 and 3 (C) 3 and 4 (D) 4 and 1

15. Match List-I and List-II and select the correct answer using the codes given below the lists:

h_m - mass transfer coefficient, D - molecular diffusion coefficient,

L - characteristic length dimension, k - thermal conductivity,

ρ - density, Cp - specific heat at constant pressure, μ- dynamic viscosity

List-I	List-II
A. Schmidt number	1. $k/(\rho c_p D)$
B. Thermal diffusivity	2. $h_m L/D$
C. Lewis number	3. $\mu/\rho D$
D. Sherwood number	4. $k/\rho C_p$

Codes:	A	B	C	D		A	B	C	D
(a)	4	3	2	1	(b)	4	3	1	2
(c)	3	4	2	1	(d)	3	4	1	2

16. Match List-I with List-II and select the correct answer using the codes given below the lists:

List-I	List-II
A. Momentum transfer	1. Thermal diffusivity
B. Mass transfer	2. Kinematic viscosity

C. Heat transfer 3. Diffusion coefficient

Codes: A	B	C	A	B	C
(a) 2	3	1	(b) 1	3	2
(c) 3	2	1	(d) 1	2	3

17. Assertion (A): Thermal diffusivity is a dimensionless quantity.
Reason (R): In M-L-T-Q system the dimensions of thermal diffusivity are $[L^2T^{-1}]$
(a) Both A and R are individually true and R is the correct explanation of A
(b) Both A and R are individually true but R is not the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

18. A furnace is made of a red brick wall of thickness 0.5 m and conductivity 0.7 W/mK. For the same heat loss and temperature drop, this can be replaced by a layer of diatomite earth of conductivity 0.14 W/mK and thickness
(a) 0.05 m (b) 0.1 m (c) 0.2 m (d) 0.5 m

19. Consider the following statements with regard to heat transfer:
(1) The temperature variations in lumped heat capacity analysis is exponential with time
(2) In situations involving simultaneous heat and mass transfer, the ratio of convective heat transfer to convective mass transfer varies with Lewis number, Le, as) (1 Le 3 Which of the above statements are correct/ (A) Both `1 and 2 (B) Neither 1 nor 2 (C) 1 only (D) 2 only

20. Consider the following statements: (1) In natural convection turbulent flow over heated vertical plate, h is independent of the characteristic length (2) In turbulent flow, non-dimensional heat transfer coefficient for natural convection over a heated vertical plate is given by) (1 3=Nu c Pr Which of the above statements is/are correct? (A) 1 only (B) Both 1 and 2 (C) 2 only (D) Neither 1 nor 2

21. A dimensionless quantity that connects the link between velocity flow field and the temperature field is
(A) Nusselt number (B) Prandtl number (C) Reynolds number (D) Grashof number

22. For a Fluid with Prandtl number Pr > 1, momentum boundary layer thickness (A) Decreases rapidly compared to the thermal boundary layer thickness (B) And thermal boundary layer thickness increases at the same rate (C) Increases rapidly compared to the thermal boundary layer thickness (D) And thermal boundary layer thickness decrease at the same rate

23. In a pipe, laminar flow in fully developed region with constant heat flux from pipe wall, bulk mean temperature of fluid
(A) and pipe wall temperature increase in flow direction
(B) and pipe wall temperature decrease in flow direction
(C) remains constant, but pipe wall temperature increases in flow direction
(D) increases but pipe wall temperature remains constant

24. For which of these configurations is a minimum temperature difference required for natural convection to set in
(A) Fluid near a heated vertical plate
(B) Fluid near a heated plate inclined at 45° to the vertical
(C) Fluid over a heated horizontal plate
(D) Fluid near a heated cylinder
25. Statement (I): A counter flow heat exchanger is more effective than a parallel flow heat exchanger. Statement (II): For same temperature limits of hot and cold fluids, the overall heat transfer coefficient of counter flow heat exchanger is more than parallel flow heat exchanger.
(A) Both Statement (I) and Statement (II) are individually true and Statement (II) is the correct explanation of statement (I) (B) Both Statement (I) and Statement (III) are individually true but Statement (III) is Not the correct explanation of statement (I) (C) Statement (I) is true but statement (II) is false (D) Statement (I) is false but statement (II) is true
26. A counter flow shell and tube exchanger having an area of 35.5 m2 , is used to heat water with hot exhaust gases. The water (Cp = 4.16kJ/kg K) flows at a rate of 2kg/sec while the exhaust gases (Cp = 1.03kJ/kg K) flow at a rate of 5.15kg/sec. If the overall heat transfer surface coefficient is 200W/m2K, the NTU for the heat exchanger is (A) 1.2 (B) 2.4 (C) 3.6 (D) 4.8
27. In a concentric double–pipe heat exchanger where one of the fluids undergoes phase change
(A) The two fluids should flow opposite to each other
(B) The two fluids should flow parallel to each other
(C) The two fluids should flow normal to each other
(D) The directions of flow of the two fluids are of no consequence

28. In a two–fluid heat exchanger, the inlet and outlet temperatures of the hot fluid are 65°C and 40°C respectively. For the cold fluid, these are 15°C and 43°C. The heat exchanger is a
(A) Parallel flow heat exchanger (B) Counter flow heat exchanger
(C) Mixed flow heat exchanger (D) Phase–change heat exchanger

29. A counter flow shell and tube heat exchanger is used to heat water with hot exhaust gases. The water (c = 4180 J/kg K) flows at the rate of 2 kg/s and the exhaust gases (c = 1000 J/kg K) flow at the rate of 5 kg/s. If the heat transfer surface area is 32 m^2 and the overall heat transfer coefficient is 200 W/m^2K, the NTU of the heat exchanger is
(A) 4.5 (B) 2.4 (C) 8.6 (D) 1.28

30. For the same type of shapes, the value of Radiation shape factor will be higher when surfaces are (A) More closer only (B) Moved further apart (C) Smaller and held closer (D) Larger and held closer
31. If a body is at 2000 K, the wavelength at which the body emits maximum amount of radiation is
(A) µ1.45 m (B) 1.45 cm (C) 0.345 cm (D) 0.345 m
32. An isothermal cubical) × ×10m 10m 10m (blackbody at 200°C is suspended in air. The total radiation emitted by this body to its surroundings will be
(A) 1702.9 kW (B) 1800.7 kW (C) 54.4 kW (D) 2838.1 kW
33. A 1 m diameter spherical cavity is maintained at a uniform temperature of 500 K. The emissivity of the material of the sphere is 0.5; One 10 mm diameter hole is drilled. The maximum rate of radiant energy streaming through the hole will be

(A) 2782 W (B) 0.139 W (C) 1392 W (D) 0.278 W

34. For a hemispherical furnace with a flat circular base of diameter D, the view factor from the dome to its base is

(A) 0.5 (B) 1 (C) 0 (D) 0.32

1.What do you understand by the lumped capacity? What are the physical assumptions necessary for a lumped capacity unsteady state analysis apply? Determine time required in minutes for a 50mm diameter steel sphere) (3 7800 kg m ,c 0.46 kJ kg K, k 35W m K− = = − = = ρ to cool from 600OC temperature to 100OC temperature if exposed to a cooling air at 30OC. The convection heat transfer coefficient is 10W/m-K.

WEBSITES:

1. http://hyperphysics.phy-astr.gsu.edu/hbasr/thermo/hetra.html
2. http://www.bbc.co.uk/schools/gcsebitesize/science/aqa_pre_2011/energy/heatrev1.shtml
3. www.design-simulation.com/ip/curriculum/misccontent/**heattransfer**.php
4. http://www.heattransfersys.com/
5. www.wiley.com › ... › Mechanical Engineering › Thermodynamics

SUBJECT EXPERTS:

1. R.K.RAJPUT.
2. S.DOMKUNDWAR.
3. S.YADAV.
4. J.P HOLMANN.
5. P.K NAG
6. S.P. Sukhatme
7. U.N. Gaitonde
8. Pradip Dutta

JOURNALS:

- Energy & Environment
- International Journal for Numerical Methods in Fluids
- HCTL Open International Journal of Technology Innovations and Research (HCTL Open IJTIR)
- HCTL Open Science and Technology Letters (HCTL Open STL)
- www.**journals**.elsevier.com/international-**journal**-of-**heat** **transfer**
- Journal of Heat transfer: ASME DC http://heattransfer.asmedigitalcollection.asme.org/journal.aspx
- International-journal-of-heat and mass transfer: **Elsevier** **http://www.journals.elsevier.com/international-journal-of-heat-and-mass-transfer/**
- Heat Transfer Research: http://www.begellhouse.com/journals/heat-transfer-research.html

SEMINARS:

- Basic modes of heat transfer
- Natural convection

- Forced convection
- Types of heat exchanger
- Phase transformation heat transfer
- Radiation laws

CASE STUDIES/SMALL PROJECTS:

- Fabrication of Shell and tube heat exchanger
- Fabrication of parallel flow heat exchanger
- Fabrication of parallel flow heat exchanger
- Exhaust gas calorimeter