SIR ISSAC NEWTON COLLEGE OF ENGINEERING &TECHNOLOGY.
(Approved by AICTE, New Delhi | Affiliated to Anna University, Chennai)
PAPPAKOIL NAGAPATTINAM – 611002 TAMILNADU INDIA
Ph : 04365-220261/7373765117| E-mail: | Website : www.sincet.in

DEPARTMENT OF MECHANICAL ENGINEERING

Course File

ME 8693 HEAT AND MASS TRANSFER

STAFF NAME : **VEERAPANDIAN.K**

SUBJECT NAME : **ME 8693 HEAT AND MASS TRANSFER**

YEAR/SEMESTER : **III/VI**

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Vision of Institution

Our vision is to impart in our students the career skills and the virtues of humanity, humaneness, honesty and vourage to enable to contirbute continually to the development of society.

Mission of Institution

Our mission is to develop, maintain and improve continuously our quality resoruces for the benefit of the society by producing a citizen group that has an everlasting urge to learn and perform.

PO1	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2	**Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations
PO4	**Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions
PO5	**Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
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
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
PO8	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9	**Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings
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
PO11	**Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member leader in a team, to manage projects and in multidisciplinary environments
PO12	**Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

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Vision of the Department

To create excellent professionals in the field of Mechanical Engineering and to uplift the quality of technical education on par with the International Standards.

Mission of the Department

1. To reinforce the fundamentals of Science and Mathematics to Mechanical Engineering and critically and relatively investigate complex mechanical systems and processes.
2. To engage in the production, expansion and practice of advanced engineering applications through knowledge sharing activities by interacting with global communities and industries.
3. To equip students with engineering ethics, professional roles, corporate social responsibility and life skills and apply them for the betterment of society.
4. To promote higher studies and lifelong learning and entrepreneurial skills and develop excellent professionals for empowering nation's economy.

PEO's

5. To enrich the technical knowledge of design, manufacturing and management of mechanical systems and develop creative and analytical thinking in research
6. To relate, strengthen and develop the theoretical knowledge of the Mechanical Engineering by exhibiting various concepts applied through diverse industrial exposures and experts' guidance.
7. Facilitate the students to communicate effectively on complex social, professional and engineering activities with strict adherence to ethical principles.
8. Create awareness for independent and lifelong learning and develop the ability to keep abreast of modern trends and adopt them for personal technological growth of the nation.

PSO's

1. To understand the basic concept of various mechanical engineering field such as design, manufacturing, thermal and industrial engineering.
2. To apply the knowledge in advanced mechanical system and processes by using design and analysis techniques.
3. To develop student's professional skills to meet the industry requirements and entrepreneurial skills for improving nation's economy stronger.

ME 8693 HEAT AND MASS TRANSFER

COURSE OUTCOMES:

Upon the completion of this course the students will be able to

C303.1 Apply heat conduction equations to different surface configurations under steady state and transient conditions and solve problems

C303.2 Apply free and forced convective heat transfer correlations to internal and external flows through/over various surface configurations and solve problems

C303.3 Explain the phenomena of boiling and condensation, apply LMTD and NTU methods of thermal analysis to different types of heat exchanger configurations and solve problems

C303.4 Explain basic laws for Radiation and apply these principles to radiative heat transfer.

C303.5 Explain the mass transfer and transfer correlations

C303.6 Knowledge about Automobile radiator heat transfer.

C303.7 Knowledge about the refrigerator heat transfering to room

ME 8693 HEAT AND MASS TRANSFER

UNIT I CONDUCTION 9+6

General Differential equation of Heat Conduction– Cartesian and Polar Coordinates – One Dimensional Steady State Heat Conduction — plane and Composite Systems – Conduction with Internal Heat Generation – Extended Surfaces – Unsteady Heat Conduction – Lumped Analysis – Semi Infinite and Infinite Solids –Use of Heisler's charts.

UNIT II CONVECTION 9+6

Free and Forced Convection - Hydrodynamic and Thermal Boundary Layer. Free and Forced Convection during external flow over Plates and Cylinders and Internal flow through tubes .

UNIT III PHASE CHANGE HEAT TRANSFER AND HEAT EXCHANGERS 9+6

Nusselt's theory of condensation - Regimes of Pool boiling and Flow boiling. Correlations in boiling and condensation. Heat Exchanger Types - Overall Heat Transfer Coefficient – Fouling Factors - Analysis – LMTD method - NTU method.

UNIT IV RADIATION 9+6

Black Body Radiation – Grey body radiation - Shape Factor – Electrical Analogy – Radiation Shields. Radiation through gases.

UNIT V MASS TRANSFER 9+6

Basic Concepts – Diffusion Mass Transfer – Fick's Law of Diffusion – Steady state Molecular Diffusion – Convective Mass Transfer – Momentum, Heat and Mass Transfer Analogy – Convective Mass Transfer Correlations.

TOTAL : 75 PERIODS

APART FROM SYLLABUS:

Automobile radiators as heat exchangers-performance-Refrigirator heat effects in live room-Earth warming due radiation-Boiler heat transfers to sorroundings.

OUTCOMES:

Upon the completion of this course the students will be able to

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

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

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

CO4 Explain basic laws for Radiation and apply these principles to radiative heat transfer.

CO5 Explain the mass transfer and transfer correlations

CO6 Knowledge about Automobile radiator heat transfer.

CO7 Knowledge about the refgirator heat transfering to room

Note:CO6,CO7 From the SRM University ,Chennai.

TEXT BOOKS:

1. Holman, J.P., "Heat and Mass Transfer", Tata McGraw Hill, 2000
2. Yunus A. Cengel, "Heat Transfer A Practical Approach", Tata McGraw Hill, 5th Edition 2015

REFERENCES:

1. Frank P. Incropera and David P. Dewitt, "Fundamentals of Heat and Mass Transfer", John Wiley & Sons, 1998.
2. Kothandaraman, C.P., "Fundamentals of Heat and Mass Transfer", New Age International, New Delhi, 1998.
3. Nag, P.K., "Heat Transfer", Tata McGraw Hill, New Delhi, 2002
4. Ozisik, M.N., "Heat Transfer", McGraw Hill Book Co., 1994.
5. R.C. Sachdeva, "Fundamentals of Engineering Heat & Mass transfer", New Age International Publishers, 2009

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PAPPAKOIL, NAGAPATTINAM.

DEPARTMENT OF MECHANICAL ENGINEERING

Academic Year (2019-2020) Even Semester

UNIT- I CONDUCTION

General Differential equation of Heat Conduction– Cartesian and Polar Coordinates – One Dimensional Steady State Heat Conduction — plane and Composite Systems – Conduction with Internal Heat Generation – Extended Surfaces – Unsteady Heat Conduction – Lumped Analysis – Semi Infinite and Infinite Solids –Use of Heisler's charts

PART – A

CO Mapping : C214.1

Q.No	Questions	BT Level	Competence	PO
1	Write the three dimensional heat transfer Poisson and Laplace equations in Cartesian co-ordinates	BTL-1	Remembering	PO1, PO2,PO12
2	Define Heat transfer?	BTL-1	Remembering	PO1, PO12
3	What are the modes of heat transfer?	BTL-1	Remembering	PO1, PO12
4	What is conduction?	BTL-1	Remembering	PO1, PO12
5	State Fourier's law of conduction.	BTL-1	Remembering	PO1, PO2,PO12
6	Define Thermal conductivity	BTL-1	Remembering	PO1, PO12
7	List down the three types of boundary conditions	BTL-1	Remembering	PO1, PO12
8	Define convection.	BTL-1	Remembering	PO1, PO12
9	Define Radiation	BTL-1	Remembering	PO1, PO12
10	State Newton's law of cooling or convection law	BTL-1	Remembering	PO1, PO2,PO12
11	Define overall heat transfer co-efficient	BTL-1	Remembering	PO1, PO12
12	Define fins or extended surfaces	BTL-1	Remembering	PO1, PO12
13	State the applications of fins	BTL-1	Remembering	PO1, PO12
14	Define fin efficiency	BTL-1	Remembering	PO1, PO12
15	Define Fin effectiveness	BTL-1	Remembering	PO1, PO12
16	What is meant by steady state heat conduction?	BTL-1	Remembering	PO1, PO12
17	What is meant by transient heat conduction or unsteady state conduction	BTL-1	Remembering	PO1, PO12
18	What is Periodic heat flow?	BTL-1	Remembering	PO1, PO12
19	What is non Periodic heat flow?	BTL-1	Remembering	PO1, PO12
20	What is meant by Newtonian heating or cooling process	BTL-1	Remembering	PO1, PO12

21	What is meant by Lumped heat analysis?	BTL-1	Remembering	PO1, PO12
22	What is meant by semi-in finite solids?	BTL-1	Remembering	PO1, PO12
23	What is meant by infinite solid	BTL-1	Remembering	PO1, PO12
24	Define Biot number.	BTL-1	Remembering	PO1, PO12
25	What is the significance of Biot number?	BTL-1	Remembering	PO1, PO12
26	What are the factors affecting the thermal conductivity?	BTL-1	Remembering	PO1, PO12
27	Explain the significance of thermal diffusivity.	BTL-2	Understanding	PO1, PO2,PO12
28	What are Heislers charts?	BTL-1	Remembering	PO1, PO12
29	Define thermal diffusivity	BTL-1	Remembering	PO1, PO12
30	Define Critical radius of thickness of insulation	BTL-1	Remembering	PO1, PO12
31	Define internal heat generation in solids	BTL-1	Remembering	PO1, PO12
	PART – B & C			
1	A hollow cylinder of 5cm ID and 10 cm OD, has an inner surface temperature of 200°C and an outer surface temperature of 100°C. If the thermal conductivity of the cylinder material is 70 W/mK. Determine the heat flow through the cylinder per unit length.	BTL-5	Evaluating	PO1, PO2,PO12
2	(i)Derive general heat conduction equation in Cartesian coordinates. (ii)A surface wall consists of 2.3cm of fire brick and 11.5cm of insulating brick having thermal conductivities of 0.72W/mk and 0.27W/mK respectively. Calculate the rate of heat loss per square meter when the temperature difference between inner and outer surface is 650K	BTL-5	Evaluating	PO1, PO2,PO12
3	A steel pipe line (K=50w/mk) of I.D. 100mm and O.D 110mm is to be covered with two layers of insulation each having a thickness of 50mm. The thermal conductivity of the first insulation material is 0.06W/mK and that of the second is 0.12 W/mK. Calculate the loss of heat per meter length of pipe and the interface temperature between the two layers of insulation when the temperature of the inside tube surface is 250oC and the outside surface of the insulation is 50oC	BTL-5	Evaluating	PO1, PO2,PO12
4	A cylinder 1m long and 5cm in diameter is placed in an atmosphere at 45oC. It is provided with 10 longitudinal straight fins of material having K=120W/mK. The height of 0.76mm thick fins is 1.27cm from the cylinder surface. The heat transfer coefficient between cylinder and atmospheric air is 17W/m2K.Calculate the rate of heat transfer and the	BTL-5	Evaluating	PO1, PO2,PO12

	temperature at the end of fins if surface temperature of cylinder is 150oC.			
5	A large slab of aluminum at a uniform temperature of 250oC is suddenly exposed to a convective environment at 50oC with a heat transfer coefficient of 500W/m2K. Estimate the temperature at a depth of 5cm after 1 hour. The thermal diffusivity and thermal conductivity of aluminum are 8.4x10-5 m2/s and 215 W/mK. respectively	**BTL-5**	**Evaluating**	**PO1, PO2,PO12**
6	Calculate the temperature in a plane 200mm from the surface of a very thick wall and also the heat flowing per unit area of this plane 10 hours after the surface temperature of the wall changes from 25oC to 800oC and remains constant thereafter. Also find the total energy taken up by the wall in 10 hours. Assume for wall material, K= 0.8w/mK and α=0.003m2/h	**BTL-5**	**Evaluating**	**PO1, PO2,PO12**
7	Derive the general heat conduction equation in cylindrical coordinates	**BTL-6**	**Creating**	**PO1, PO2,PO12**
8	Derive the general heat conduction equation for a hollow cylinder	**BTL-6**	**Creating**	**PO1, PO2,PO12**

UNIT- II CONVECTION

Properties of steam – Ranking cycle—Boilers and its accessories– Basic thermodynamics of refrigerators and heat pumps.- Basics of Heat transfer

PART – A

CO Mapping : C214.2

Q.No	Questions	BT Level	Competence	PO
1	What is dimensional analysis	BTL-1	Remembering	**PO1, PO12**
2	Mention the significance of velocity and thermal boundary layer	BTL-1	Remembering	**PO1, PO12**
3	State Buckingham’s theorem	BTL-1	Remembering	**PO1, PO2,PO12**
4	What are the advantages of dimensional analysis	BTL-1	Remembering	**PO1, PO12**
5	What are the limitations of dimensional analysis	BTL-1	Remembering	**PO1, PO12**
6	Define Reynolds number	BTL-1	Remembering	**PO1, PO12**
7	Define Prandtl number	BTL-1	Remembering	**PO1, PO12**
8	Define Nusselts Number	BTL-1	Remembering	**PO1, PO12**
9	Define Grashof number	BTL-1	Remembering	**PO1, PO12**
10	Define Stanton number	BTL-1	Remembering	**PO1, PO12**
11	What is meant by Newtonian and non- Newtonian fluids	BTL-1	Remembering	**PO1, PO12**
12	What is meant by laminar flow and turbulent flow	BTL-1	Remembering	**PO1, PO12**
13	What is hydro dynamics boundary layer	BTL-1	Remembering	**PO1, PO12**
14	What is thermal boundary layer	BTL-1	Remembering	**PO1, PO12**
15	Define convection.	BTL-1	Remembering	**PO1, PO12**

16	What is meant by free or natural convection	**BTL-1**	**Remembering**	**PO1, PO12**
17	What is forced convection	**BTL-1**	**Remembering**	**PO1, PO12**
18	What is the form of equation used to calculate transfer for flow through cylindrical pipes	**BTL-1**	**Remembering**	**PO1, PO2,PO12**
19	What are the dimensional parameters used in forced convection	**BTL-1**	**Remembering**	**PO1, PO12**
20	Define boundary layer thickness	**BTL-1**	**Remembering**	**PO1, PO12**
21	Indicate the concept of significance of boundary layer	**BTL-1**	**Remembering**	**PO1, PO12**
22	Define displacement thickness.	**BTL-1**	**Remembering**	**PO1, PO12**
23	Define momentum thickness	**BTL-1**	**Remembering**	**PO1, PO12**
24	Define energy thickness	**BTL-1**	**Remembering**	**PO1, PO12**
25	Define bulk temperature	**BTL-1**	**Remembering**	**PO1, PO12**
26	Define fouling factor	**BTL-1**	**Remembering**	**PO1, PO12**
27	Parameters that influence fouling resistances	**BTL-1**	**Remembering**	**PO1, PO12**
28	Give examples of external flow	**BTL-1**	**Remembering**	**PO1, PO12**
29	Write continuity equation	**BTL-1**	**Remembering**	**PO1, PO12**
30	Write momentum equation	**BTL-1**	**Remembering**	**PO1, PO12**
31	Write energy equation	**BTL-1**	**Remembering**	**PO1, PO12**
	PART – B & C			
1	Air at 20°C at 3m/s flows over a thin plate of 2m long and 1m wide. Estimate the boundary layer thickness at the trailing edge, total drag force, mass flow of air between x = 30 cm and x = 80 cm. Take v = 15 x 106 and p = 1.17kg/m^3	**BTL-5**	**Evaluating**	**PO1, PO2,PO12**
2	Calculate the convective heat transfer from a radiator 0.5m wide and 1m high at 84°C in a room at 20°C. treat the radiator as a vertical plate	**BTL-5**	**Evaluating**	**PO1, PO2,PO12**
3	(i) Define the velocity boundary layer and thermal boundary layer thicknesses for flow over a flat plate (ii) Atmospheric air at 150°C with a velocity of 1.25 m/s over a 2 m long flat plate whose temperature is 25°C. Determine the average heat transfer coefficient and the rate of heat transfer for a plate width of 0.5 m.	**BTL-1, BTL-5**	**Remembering Evaluating**	**PO1, PO2,PO12**
4	A 6m long section of an 8 cm diameter horizontal hot water pipe passes through a large room in which the air and walls are at 20°C. The pipe surface is at 70°C and the emissivity of the pipe surface is 0.7. Find the rate of heat loss from the pipe by natural convection and radiation	**BTL-1**	**Remembering**	**PO1, PO2,PO12**

5	(i) Explain the development of velocity boundary layer for flow over a flat plate. (ii) Engine oil at 60°C flows with a velocity of 2 m/s over a 5 m long flat plate whose temperature is 20°C. Determine the drag force exerted by oil on the plate and the rate of heat transfer for a plate width of 1 m.	**BTL-2, BTL-5**	**Understanding Evaluating**	**PO1, PO2,PO12**
6	(i)Define bulk temperature and thermal entry length for tube flows. (ii) A metallic cylinder of 12.7 mm diameter and 94 mm length is heated internally by an electric heater and its surface is cooled by air. The free stream air velocity and temperatures are respectively 10 m/s and 26.2°C. Under steady operating conditions, heat dissipated by the cylinder is 39.1 W and its avenge surface temperature is 128.4°C. Determine the convection heat transfer coefficient from the above experiment. Also find the convection heat transfer coefficient from an appropriate correlation and compare both	**BTL-1, BTL-5**	**Remembering Evaluating**	**PO1, PO2,PO12**
7	A steam pipe 20 cm outside diameter runs horizontally in a room at 23°C.Take the outside surface temperature of pipe as 165°C. Determine the heat loss per meter length of the pipe	**BTL-5**	**Evaluating**	**PO1, PO2,PO12**
8	(i) Define Reynold's, Prandtl, Nusselt and Grashoff number and give their expressions. (8) [NOV/DEC 2010] (ii) Air is flowing over a flat plate 5 m long and 2.5 m wide with a velocity of 4 m/s at 15°C. If p= 1.208 kg/m3 and u= 1.47 x 10-5 m2/s, calculate the length of plate over which the boundary layer is laminar and thickness of the boundary layer (laminar), shear stress at the location where boundary layer ceases to be laminar and the total drag force on the both sides on that portion of the plate where boundary layer is laminar	**BTL-1, BTL-5**	**Remembering Evaluating**	**PO1, PO2,PO12**
9	(i) Draw the profile of a boundary layer on a flat plate showing the velocity profiles and explain the significance of boundary layer. Define thermal boundary layer. (6) [NOV/DEC 2010] (ii) A vertical cylinder 1.5 m high and 180 mm in diameter is maintained at 100°C in an atmosphere of 20°C. Calculate the heat loss by free convection from the surface of the cylinder. Assume properties of air as p = 1.06 kg/m3 and u = 18.97x 10-6 m^2/s, cp = 1.004kJ/kg°C and k = 0.1042 kJ/m.K.	**BTL-1, BTL-5**	**Remembering Evaluating**	**PO1, PO2,PO12**

UNIT III	PHASE CHANGE HEAT TRANSFER AND HEAT EXCHANGERS			
Nusselt's theory of condensation - Regimes of Pool boiling and Flow boiling. Correlations in boilingand condensation. Heat Exchanger Types - Overall Heat Transfer Coefficient – Fouling Factors -Analysis – LMTD method - NTU method.				
PART – A				
CO Mapping : C214.3				
Q.No	Questions	**BT Level**	**Competence**	**PO**
1	Define boiling	**BTL-1**	**Remembering**	**PO1, PO12**
2	Differentiate between pool boiling and forced convection boiling	**BTL-4**	**Analyzing**	**PO1, PO12**
3	What advantage does the Effectiveness - NTU method has over the LMTD method	**BTL-1**	**Remembering**	**PO1, PO12**
4	What is meant by condensation	**BTL-1**	**Remembering**	**PO1, PO12**
5	Give the application of boiling and condensation	**BTL-1**	**Remembering**	**PO1, PO12**
6	What is meant pool boiling	**BTL-1**	**Remembering**	**PO1, PO12**
7	What are the modes of condensation	**BTL-1**	**Remembering**	**PO1, PO12**
8	What is Film wise condensation	**BTL-1**	**Remembering**	**PO1, PO12**
9	What is Drop wise condensation	**BTL-1**	**Remembering**	**PO1, PO12**
10	What is heat exchange	**BTL-1**	**Remembering**	**PO1, PO12**
11	What are the types of heat exchanger	**BTL-1**	**Remembering**	**PO1, PO12**
12	What is meant by in direct contact heat exchangers	**BTL-1**	**Remembering**	**PO1, PO12**
13	What is meant by Regenerators	**BTL-1**	**Remembering**	**PO1, PO12**
14	What is meant by Remunerators or surface heat exchangers	**BTL-1**	**Remembering**	**PO1, PO12**
15	What is meant by parallel flow heat exchangers	**BTL-1**	**Remembering**	**PO1, PO12**
16	What is meant by Counter flow heat exchangers	**BTL-1**	**Remembering**	**PO1, PO12**
17	What is meant by cross flow heat exchangers	**BTL-1**	**Remembering**	**PO1, PO12**
18	What is meant by Shell and tube heat exchangers	**BTL-1**	**Remembering**	**PO1, PO12**
19	What is meant by Compact heat exchangers	**BTL-1**	**Remembering**	**PO1, PO12**
20	What is meant by LMTD	**BTL-1**	**Remembering**	**PO1, PO12**
21	What is meant Fouling factor	**BTL-1**	**Remembering**	**PO1, PO12**
22	What is meant by Effectiveness	**BTL-1**	**Remembering**	**PO1, PO12**
23	How film wise differ from drop wise condensation	**BTL-1**	**Remembering**	**PO1, PO12**
24	Give the application of boiling and condensation	**BTL-1**	**Remembering**	**PO1, PO12**
25		**BTL-1**	**Remembering**	**PO1, PO12**
26	Give the merits of drop wise condensation	**BTL-1**	**Remembering**	**PO1, PO12**
27	What is meant by NTU? Give its expression	**BTL-1**	**Remembering**	**PO1, PO12**
PART – B & C				
1	Consider laminar film condensation of a stationary vapour on a vertical flat plate of length L and width b. Derive an expression for the average heat transfer coefficient. State the assumptions made	**BTL-6**	**Creating**	**PO1, PO2,PO12**
2	A vertical tube of 50mm outside diameter and 2m long is exposed to steam at atmospheric pressure. The outer surface of the tube is maintained at the temperature of 84^{o}C by circulating cold water through the tube.	**BTL-5**	**Evaluating**	**PO1, PO2,PO12**

	determine the rate of heat transfer and also the condenser mass flow rate			
3	(i) Discuss critical heat flux and Leidenfrost point. (ii) A 10 by 10 array of horizontal tubes of 1.27 cm diameter is exposed to pure steam at atmospheric pressure. If the tube wall temperature is 98°C, Estimate the mass of steam condensed assuming a tube length of 1.5 m.	**BTL-6**	**Creating**	**PO1, PO2,PO12**
4	Derive the L MT D for a parallel flow heat exchanger stating the assumptions	**BTL-6**	**Creating**	**PO1, PO2,PO12**
5	A counter flow double pipe heat exchanger using superheated steam is used to hot water at the rate of 10500 kg/h. The steam enters the heat exchanger at 180^{o}C and leaves at 130^{o}C. The inlet and exit temperature of water are 30^{o}C and 80^{o}C respectively. If overall heat transfer from steam to water is 814W/m^{o}C. Calculate the heat transfer area. What would be the increase in area if the fluid flows were parallel	**BTL-5**	**Evaluating**	**PO1, PO2,PO12**
6	Oil (Cp=3.6KJ/Kg^{o}C) at 100^{o}C flows at the rate of 3000Kg/h and enters into a parallel flow heat exchanger. Cooling water(Cp=4.2KJ/Kg^{o}C) enters the heat exchanger at 10^{o}C at the rate of 50000Kg/h. The heat transfer area is 10m^2 and U=1000W/m^{2o}C calculate the following (i) The outlet temperature of oil, and water (ii) The maximum possible outlet temperature of water.	**BTL-5**	**Evaluating**	**PO1, PO2,PO12**

UNIT IV **RADIATION**				
Black Body Radiation – Grey body radiation - Shape Factor – Electrical Analogy – Radiation Shields. Radiation through gases.				
PART – A				
CO Mapping : C214.4				
Q.No	**Questions**	**BT Level**	**Competence**	**PO**
1	Define Radiation	**BTL-1**	**Remembering**	**PO1, PO12**
2	What is max planck theory of black body radiation	**BTL-1**	**Remembering**	**PO1, PO12**
3	What is thermal radiation	**BTL-1**	**Remembering**	**PO1, PO12**
4	Define emissive power	**BTL-1**	**Remembering**	**PO1, PO12**
5	Define monochromatic emissive power.	**BTL-1**	**Remembering**	**PO1, PO12**
6	What is meant by absorptive	**BTL-1**	**Remembering**	**PO1, PO12**
7	What is meant by reflectivity	**BTL-1**	**Remembering**	**PO1, PO12**
8	What is meant by transmissivity	**BTL-1**	**Remembering**	**PO1, PO12**
9	What is black body	**BTL-1**	**Remembering**	**PO1, PO12**
10	State Wien's displacement law	**BTL-1**	**Remembering**	**PO1, PO12**
11	State the Stefan -Boltzmann law	**BTL-1**	**Remembering**	**PO1, PO12**
12	Define Emissivity.[	**BTL-1**	**Remembering**	**PO1, PO12**
13	What is meant by gray body	**BTL-1**	**Remembering**	**PO1, PO12**
14	State Kirchoff's law of radiation	**BTL-1**	**Remembering**	**PO1, PO12**
15	Define intensity of radiation	**BTL-1**	**Remembering**	**PO1, PO12**
16	State Lambert's cosine law	**BTL-1**	**Remembering**	**PO1, PO12**
17	What is the purpose of radiation shield	**BTL-1**	**Remembering**	**PO1, PO12**
18	Define Irradiation	**BTL-1**	**Remembering**	**PO1, PO12**
19	What is radiosity	BTL-1	Remembering	**PO1, PO12**
20	What are the assumptions made to calculate radiation exchange between the surfaces	**BTL-1**	**Remembering**	**PO1, PO12**
21	What is meant by shape factor and mention its physical significance	**BTL-1**	**Remembering**	**PO1, PO12**
22	Discuss the radiation characteristics of carbondioxide and water vapour.	**BTL-1**	**Remembering**	**PO1, PO12**
23	Give reciprocity theorem	**BTL-1**	**Remembering**	**PO1, PO12**
24	Define summation rule	**BTL-1**	**Remembering**	**PO1, PO12**
25	Define symmetry rule	**BTL-1**	**Remembering**	**PO1, PO12**
26	What is mean by reradiating surfaces	**BTL-1**	**Remembering**	**PO1, PO12**
27	What is mean by spectral directional emissivity	**BTL-1**	**Remembering**	**PO1, PO12**
28	Describe green house effect	**BTL-1**	**Remembering**	**PO1, PO12**
29	What is mean by solar heat gain coefficient(SHGC)	**BTL-1**	**Remembering**	**PO1, PO12**
30	Describe direct method	**BTL-1**	**Remembering**	**PO1, PO12**
31	What is mean by Beer's Law	**BTL-1**	**Remembering**	**PO1, PO12**
32	What is mean by fully developed region	**BTL-1**	**Remembering**	**PO1, PO12**
PART – B & C				

1	Emissivities of two large parallel plates maintained at 800°C and 300°C are 0.3 and 0.5 respectively. Find the net radiation heat exchange per square meter for this plate. Find the percentage reduction in heat transfer when a polished aluminum radiation shield (ε=0.05) is placed between them. Also find the temperature of shield.	**BTL-5**	**Evaluating**	**PO1, PO2,PO12**
2	Two large parallel plates of 1mx1m spaced 0.5m apart in a very large room whose walls are at 27°C. The plates are at 900°C and 400°C with emissivities 0.2 and 0.5 respectively. Find the net heat transfer to each plate and to the room	**BTL-1**	**Remembering**	**PO1, PO2,PO12**
3	Derive the radiation exchange between (i)Large parallel gray surfaces and (ii) small gray bodies	**BTL-6**	**Creating**	**PO1, PO2,PO12**
4	i) Two black square plates of size 1.0 by 1.0m are placed parallel to each other at a distance of 0.4m. One plate is maintained at a temperature of 900°C and the other at 400°C. Find the net exchange of energy due to radiation between the two plates ii) Two circular discs of diameter 20cm each are placed 2m apart. Calculate the radiation heat exchange for these plates if these are maintained at 800°C and 300°C respectively and their corresponding emissivity's are 0.3 and 0.5	**BTL-5**	**Evaluating**	**PO1, PO2,PO12**
5	A pipe carrying steam having an outside diameter of 20cm runs in a large room, and is exposed to air at a temperature of 30°C. The pipe surface temperature is 200°C. Find the heat loss per meter length of the pipe by convection and radiation taking the emissivity of the pipe surface as 0.8.	**BTL-1**	**Remembering**	**PO1, PO2,PO12**
6	A flue gas at temperature, T_g=950°C total pressure 1 atm, and containing 10% CO_2 and 45 H_2O, flows over a bank of tubes arranged in an equilateral triangular arrangement with tubes of 44mm dia having longitudinal and cross pitches each equal to 2D, Assuming the tube surfaces as gray with an emissivity of 0.8 and at a uniform temperature Tw=500°C, determine the net radiation exchange between the gas and the tube walls. Also calculate the coefficient of heat transfer by radiation.	**BTL-5**	**Evaluating**	**PO1, PO2,PO12**

UNIT – V – **MASS TRANSFER**				
Basic Concepts – Diffusion Mass Transfer – Fick’s Law of Diffusion – Steady state Molecular Diffusion– Convective Mass Transfer – Momentum, Heat and Mass Transfer Analogy –Convective MassTransfer Correlations.				
PART – A				
CO Mapping : C214.5				
Q.No	**Questions**	**BT Level**	**Competence**	**PO**
1	Define Schmidt Number	**BTL-1**	**Remembering**	**PO1, PO12**
2	What are the attributes of Fick's law of diffusion	**BTL-1**	**Remembering**	**PO1, PO12**
3	Define molar and mass concentration	**BTL-1**	**Remembering**	**PO1, PO12**
4	Define Scherwood number	**BTL-1**	**Remembering**	**PO1, PO12**
5	Define Mass Concentration.	**BTL-1**	**Remembering**	**PO1, PO12**
6	Define mass fraction	**BTL-1**	**Remembering**	**PO1, PO12**
7	Define mole fractions	**BTL-1**	**Remembering**	**PO1, PO12**
8	State Fick’s Law of Diffusion	**BTL-1**	**Remembering**	**PO1, PO12**
9	Give the examples of mass transfer	**BTL-1**	**Remembering**	**PO1, PO12**
10	What are the modes of mass transfer	**BTL-1**	**Remembering**	**PO1, PO12**
11	What is molecular diffusion	**BTL-1**	**Remembering**	**PO1, PO12**
12	What is Eddy diffusion	**BTL-1**	**Remembering**	**PO1, PO12**
13	What is convective mass transfer	**BTL-1**	**Remembering**	**PO1, PO12**
14	What is free convective mass transfer	**BTL-1**	**Remembering**	**PO1, PO12**
15	Define forced convective mass transfer	**BTL-1**	**Remembering**	**PO1, PO12**
16	Give two examples of convective mass transfer	**BTL-1**	**Remembering**	**PO1, PO12**
17	Define molar concentration	**BTL-1**	**Remembering**	**PO1, PO12**
18	Define mole fraction	**BTL-1**	**Remembering**	**PO1, PO12**
19	Define molar density	**BTL-1**	**Remembering**	**PO1, PO12**
20	What is mean by partial density	**BTL-1**	**Remembering**	**PO1, PO12**
21	What is mean by binary mixture	**BTL-1**	**Remembering**	**PO1, PO12**
22	What is mean by soret effect	**BTL-1**	**Remembering**	**PO1, PO12**
23	Describe the two mechanisms of mass transfer	**BTL-1**	**Remembering**	**PO1, PO12**
24	Explain Mass Transfer Coefficient	**BTL-5**	**Evaluating**	**PO1, PO12**
25	Define diffusion velocity	**BTL-1**	**Remembering**	**PO1, PO12**
26	Define mass average velocity of the flow	**BTL-1**	**Remembering**	**PO1, PO12**
27	Define permeability.	**BTL-1**	**Remembering**	**PO1, PO12**
28	What is mean by vapor barriers either vapor barriers	**BTL-1**	**Remembering**	**PO1, PO12**
29	What is mean by moving medium	**BTL-1**	**Remembering**	**PO1, PO12**
30	Define homogeneous fluid	**BTL-1**	**Remembering**	**PO1, PO12**
31	Define non-homogeneous fluid	**BTL-1**	**Remembering**	**PO1, PO12**
32	What is mean by simultaneous heat and mass transfer	**BTL-1**	**Remembering**	**PO1, PO12**

PART B& C				
1	Dry air at 27°C and 1 atm flows over a wet flat plate 50cm long at a velocity of 50m/s. Calculate the mass transfer coefficient of water vapor in air at the end of the plate.	**BTL-5**	**Evaluating**	**PO1, PO2,PO12**
2	(i) What are the assumptions made in the 1-D transient mass diffusion problems? (ii) The dry bulb and wet bulb temperature recorded by a thermometer in moist air are 27°C and 17°C respectively. Determine the specific humidity of air assuming the following values: Prandtl Number=0.74, Schmidt Number =0.6, Specific heat at constant pressure=1.004 KJ/KgK, pressure=1.0132x105 N/m^2	**BTL-5**	**Evaluating**	**PO1, PO2,PO12**
3	(i) How does mass transfer differ from bulk fluid motion ? State Fick's law of diffusion (ii)An open pan of 20cm diameter and 8cm depth contains water at 25°C and is exposed to dry atmospheric air. Assuming the rate of diffusion of water as 8.54x10-4 Kg/h, find the diffusion coefficient.	**BTL-1**	**Remembering**	**PO1, PO2,PO12**
4	i) Explain the Ficks first and second laws of diffusion ii) Explain the phenomenon of equimolar counter diffusion. Drive an expression for equimolar counter diffusion between two gases or liquids	**BTL-2**	**Understanding**	**PO1, PO2,PO12**
5	A mixture of O_2 and N_2 with their partial pressures in the ratio 0.21 to 0.79 is in a container at 25°C. Calculate the molar concentration, the mass density, the mole fraction, and the mass fraction of each species for a total pressure of 1 bar. What would be the average molecular weight of the mixture	**BTL-1**	**Remembering**	**PO1, PO2,PO12**
6	CO_2 and air experience equimolar counter diffusion in a circular tube whose length and diameter are 1m and 50mm respectively. The system is at a total pressure of 1 atm and a temperature of 25°C. The ends of the tube are connected to large chambers in which the species concentrations are maintained at fixed values. The partial pressure of CO_2 at one end is 190mm of Hg while at the other end is 95mm Hg. Estimate the mass transfer rate of CO_2 and air through the tube	**BTL-5**	**Evaluating**	**PO1, PO2,PO12**