K S INSTITUTE OF TECHNOLOGY BANGALORE

MECHANICAL ENGINEERING DEPARTMENT

COURSE FILE

NAME OF THE STAFF	: PARASHURAM .A.K
SUBJECT CODE/NAME	: 15ME63/ HEAT TRANSFER
SEMESTER/YEAR	: VI/ III
ACADEMIC YEAR	: 2018-2019
BRANCH	: MECANICAL ENGINEERING

COURSE INCHARGE

HOD

Head of the Department
Dept. of Mechanical Engg.
K.S. Institute of Technology
Bengaluru - 560 109.

CHIEF ACADEMIC COORDINATOR

PRINCIPAL

PRINCIPAL
K.S. INSTITUTE OF TECHNOLOGY
BENGALURU - 560 109.

K. S. INSTITUTE OF TECHNOLOGY

#14, Raghuvanahalli, Kanakapura Main Road, Bengaluru-5600109

DEPARTMENT OF MECHANICAL ENGINEERING

Course File Contents

Sl. No.	Particulars
1	Front Page
2	Vision, Mission of Institute and Department
3	PEO's, PSO's and PO's
4	CO PO PSO Mapping
5	Calendar of Events of Department & College
6	Student Details
7	Individual and Class Time Table
8	Syllabus
9	Lesson Plan
10	Assignment Questions with Scheme
11	IA question Paper with Scheme
12	All IA marks and final AVG marks
13	Slow Learners: Tutorial classes conducted prooft
14	Advance Learners: Challenging questions, Question papers from other regional universities, IIT, NIT, Competitive Exam Question Papers - GATE/IES, Mini projects etc.
15	Pedagogy Report and Proofs (Proof of usage of ICT Tools)
16	Content beyond syllabus Material (if any)
17	Question Bank for each Module
18	Previous year VTU Question papers, Scheme for evaluation
19	Course end Survey
20	CO PO attainment

K. S. INSTITUTE OF TECHNOLOGY

VISION: "To impart quality technical education with ethical values, employable skills and research to achieve excellence"

MISSION:

- To attract and retain highly qualified, experienced & committed faculty.
- To create relevant infrastructure
- Network with industry & premier institutions to encourage emergence of new ideas by providing research & development facilities to strive for academic excellence
- To inculcate the professional & ethical values among young students with employable skills & knowledge acquired to transform the society

DEPARTMENT OF MECHANICAL ENGINEERING

VISION: "To groom incumbents to compete with their professional peers in mechanical engineering that brings recognition"

MISSION:

- To impart sound fundamentals in mechanical engineering
- To expose students to new frontiers
- To achieve engineering excellence through experiential learning and team work.

PROGRAM EDUCATIONAL OBJECTIVES (PEO'S)

PEO1: To produce graduates who would have developed a strong background in basic science and mathematics and ability to use these tools in Mechanical Engineering.

PEO2: To prepare graduates who have the ability to demonstrate technical competence in their fields of Mechanical Engineering and develop solutions to the problems.

PEO3: To equip graduates to function effectively in a multi-disciplinary environment individually, within a global, societal, and environmental context.

PROGRAM SPECIFIC OUTCOMES (PSO'S)

It is expected that a student in mechanical engineering will possess an:

PSO1: Ability to apply concept of mechanical engineering to design a system, a component or a process/system to address a real world challenges

PSO2: Ability to develop effective communication, team work, entrepreneurial and computational skills

PROGRAM OUTCOMES (POs)

Engineering Graduates will be able to:

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

2. **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.

3. **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.

4. **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.

5. **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.

6. **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.

7. **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.

8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

9. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

10. 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.

11. 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 and leader in a team, to manage projects and in multidisciplinary environments.

12. 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.

KSIT Bangalore

DEPARTMENT OF MECHANICAL ENGINEERING

Subject Code : 15ME63 **Subject : HEAT TRANSFER**
Faculty: Parashuram A K **Academic Year : 2018-2019**
Class:VI Semester A **Department : Mechanical**

Course Objectives

The course objective is to make students to

- Study the modes of heat transfer.
- Learn how to formulate and solve 1-D steady and unsteady heat conduction problems.
- Apply empirical correlations for fully-developed laminar, turbulent internal flows and external boundary layer convective flow problems.
- Study the basic principles of heat exchanger analysis and thermal design.
- Understand the principles of boiling and condensation including radiation heat transfer related engineering problems.

Course Outcomes:

Students will be able to

CO1 Identify the three modes of heat transfer and construct conduction heat transfer equations for composite bodies make use of both sizing and rating methods	Apply (K3)
CO2: Construct the fins to enhance heat transfer from a surface and solve for unsteady heat conduction rate.	Apply(K3)
CO3: Select the type of correlation to be used suitably so as to experiment with convection heat transfer coefficient for various applications	Apply (K3)
CO4: Make use of concept of the radiation calculate heat transfer rate from black bodies, real surfaces ,thermal shield and Utilize the methods, to find the exit temperature of fluid and size of heat exchangers	Apply (K3)
CO5: Experiment with the effect of cavitations and fouling due to boiling and condensation of fluid and Evaluate two-dimensional heat conduction equations	Apply (K3)

CO-PO Mapping

CO	PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
	K-level	K3	K4	K5	K5	K6	K4	K2	K3	K3	K2	K3	K3
CO1	**K3**	3	2	1	1	-	-	-	-	-	1	-	**1**
CO2	**K3**	3	2	1	1	-	-	-	-	-	1	-	**1**
CO3	**K3**	3	2	1	1	-	-	-	-	-	1	-	**1**
CO4	**K3**	3	2	1	1	-	-	-	-	-	1	-	**1**
CO5	**K4**	3	3	2	2	-	-	-	-	-	1	-	**1**
CO6	**K5**	3	3	3	3	1	-	-	-	-	1	-	**1**
15ME63	**Before CBS**	3	2	1	1	-	-	-	-	-	2	-	**1**
	After CBS	**3**	**2**	**1**	**1**	-	-	-	-	-	**1**	-	**1**

CO – PSO mapping

CO	PSO1	PSO2
CO1	1	2
CO2	1	2
CO3	1	2
CO4	1	2
CO5	1	2
CO6	1	2
15ME63		

3	Strong Contribution
2	Moderate Contribution
1	Weak Contribution

Signature of Course in charge

Signature of Module Coordinator

Signature of HOD/ME

Head of the Department
Dept. of Mechanical Engg.
K.S. Institute of Technology
Bengaluru - 560 109.

Signature of Chief Academic Coordinator

Signature of Principal

K.S. INSTITUTE OF TECHNOLOGY
BENGALURU - 560 109.

K.S INSTITUT E OF TECHNOLOGY, Bengaluru-109

CALENDAR OF EVENTS: EVEN SEMESTER (2018-2019)

SESSION: FEB 2019 – JUNE 2019

Week No.	Month	Day						Days	Activities	DepartmentActivities
		Mon	Tue	Wed	Thu	Fri	Sat			
1	Feb			6*	7	8	9	4	6-commencement of higher semester 9-Monday time table	
2	Feb	11	12	13	14	15	[redacted]	5		
3	Feb	18	19	20	21	22	23	6	23-Tuesday time table	
4	Feb/Mar	25*	26	27	28	1	[redacted]	5	25-commencement of second semester	28- Unveiling of Baja Vehicle
5	Mar	4H	5	6	7	8	9TA	5	4 - Maha sivarathri 9-Wednesday time table	6- Unveiling of Go-Kart Vehicle
6	Mar	11T1	12T1	13T1	14	15	16*	6	16-sports day T1 - Higher semester	
7	Mar	18	19BV	20ASD	21	22	23DH	5		24- Graduation Day
8	Mar	25	26	27	28	29	30	6	30-Monday time table	
9	Apr	1	2	3	4	5	6H	5	6-Ugadhi	5- Industrial Visit for VI Semester to Solar Power Plant
10	Apr	8	9	10	11	12	13	6	13- Tuesday time table	8th to 10th- Workshop on Modelling & Analysis By Prof. Nagabhushana M
11	Apr	15	16TA	17H	18T2	19H	20T2	4	17-Mahaveera Jayanthi 19-Good Friday T2- Higher semester and T1 second semester	
12	Apr	22T2	23	24	25	26	27BV	6	27-Wednesday time table	
13	Apr/May	29ASD	30	1H	2	3	[redacted]	4	1-May Day	
14	May	6	7H	8	9	10	11	5	7-Basava Jayanthi 11-Monday time table	8th to 10th - Industrial Visit for IV Semester to GTTC
15	May	13LT	14LT	15LT	16LT	17LT	[redacted]	5		
16	May	20T3	21T3	22T3	23*	24	25	6	23-Last working day of highersemester T3-Higher semester and T2 second semester 25-Tuesday time table	
17	May	27	28	29	30	31	[redacted]	5		
18	June	3LT	4LT	5H	6LT	7LT	8LT	5	5 - Ramzon 8-Wednesday time table	
19	June	10	11	12	13T3	14T3	15T3	6	T3 - second semester	
20	June	17*						1	17-Last working day of second semester	

TOTAL NO. of Working Days: 100

H	Holiday
BV	Blue Book Verification
T1,T2, T3	Tests 1,2, 3
ASD	Attendance & Sessional Display
DH	Declared Holiday
LT	Lab Test
TA	Test attendance
FA	Final attendance

Total Number of working days (Excluding holidays and Tests)

Monday	17
Tuesday	17
Wednesday	17
Thursday	17
Friday	17
Total	**85**

Higher semester = 81

Second semester = 85

Head of the Department
Dept. of Mechanical Engg.
K.S. Institute of Technology
Beng... 560 109

K.S INSTITUT E OF TECHNOLOGY, Bengaluru-109

CALENDAR OF EVENTS: EVEN SEMESTER (2018-2019)

SESSION: FEB 2019 – JUNE 2019

Week No.	Month	Day						Days	Activities	DepartmentActivities
		Mon	Tue	Wed	Thu	Fri	Sat			
1	Feb			6*	7	8	9	4	6-commencement of higher semester 9-Monday time table	
2	Feb	11	12	13	14	15	16DH	5		
3	Feb	18	19	20	21	22	23	6	23-Tuesday time table	
4	Feb/Mar	25*	26	27	28	1	2DH	5	25-commencement of second semester	28- Unveiling of Baja Vehicle
5	Mar	4H	5	6	7	8	9TA	5	4 - Maha sivarathri 9-Wednesday time table	6- Unveiling of Go-Kart Vehicle
6	Mar	11T1	12T1	13T1	14	15	16*	6	16-sports day T1 - Higher semester	
7	Mar	18	19BV	20ASD	21	22	23DH	5		24- Graduation Day
8	Mar	25	26	27	28	29	30	6	30-Monday time table	
9	Apr	1	2	3	4	5	6H	5	6-Ugadhi	5- Industrial Visit for V Semester to GTTC
10	Apr	8	9	10	11	12	13	6	13- Tuesday time table	8th to 10th- Workshop on Modelling & Analysis By Nagabhushana M
11	Apr	15	16TA	17H	18T2	19H	20T2	4	17-Mahaveera Jayanthi 19-Good Friday T2- Higher semester and T1 second semester	
12	Apr	22T2	23	24	25	26	27BV	6	27-Wednesday time table	
13	Apr/May	29ASD	30	1H	2	3	4DH	4	1-May Day	
14	May	6	7H	8	9	10	11	5	7-Basava Jayanthi 11-Monday time table	
15	May	13LT	14LT	15LT	16LT	17LT	[illegible]	5		
16	May	20T3	21T3	22T3	23*	24	25	6	23-Last working day of highersemester T3-Higher semester and T2 second semester 25-Tuesday time table	
17	May	27	28	29	30	31	[illegible]	5		
18	June	3LT	4LT	5H	6LT	7LT	8LT	5	5 - Ramzon 8-Wednesday time table	
19	June	10	11	12	13T3	14T3	15T3	6	T3 - second semester	
20	June	17*						1	17-Last working day of second semester	
TOTAL NO. of Working Days: 100										

H	Holiday
BV	Blue Book Verification
T1,T2, T3	Tests 1,2, 3
ASD	Attendance & Sessional Display
DH	Declared Holiday
LT	Lab Test
TA	Test attendance
FA	Final attendance

Total Number of working days (Excluding holidays and Tests)

Monday	17
Tuesday	17
Wednesday	17
Thursday	17
Friday	17
Total	85

Higher semester = 81

Second semester = 85

K S Institute of Technology

Student list of Sixth Semester A Section

Sl No.	Name	USN	Student Mobile	Email
1	BHARATH R	1KS15ME015	7892046426	bharathbharu32@gmail.com
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4	KIRAN NAGESH	1KS15ME034	9902279602	
5	MAHANTESH	1KS15ME042	7353120114	
6	MUTTURAJ VKESANUR	1KS15ME046	7975204665	mutturajvk123@gmail.com
7	N RAMAKRISHNA	1KS15ME048	9019906565	nramakrshna@gmail.com
8	THEJAS R	1KS15ME058	9945106045	
9	THEJAS CHANDRA K N	1KS15ME098	9986580608	thejaskn@gmail.com
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13	ABHILASH S	1KS16ME004	9986504115	abhilash.srivtsa@gmail.com
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15	ABHISHEK RAJ	1KS16ME007	9513800976	vikramabhishekkumar@gmail.com
16	AMOGHA M KEKUDA	1KS16ME008	9108451064	mkekuda@gmail.com
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21	BHUVAN BHARADWAJ V K	1KS16ME013	8310353623	bhuvanvk@hotmail.com
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23	CHIRAG B P	1KS16ME015	7349071590	chirag.bp.98@gmail.com
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30	HEMANTH KUMAR D L	1KS16ME025	9743000196	hemanth1898kumar@gmail.com
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48	NAGARJUN S	1KS16ME048	9481616977	nagarjun.arjun1212@gmail.com
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65	SAGAR N	1KS16ME073	8884103319	sagarn1598@gmail.com
66	SHAIK MOINUDDIN	1KS16ME075	7411799341	shaikmoinuddin02@gmail.com
67	SHARATH S YADAV	1KS16ME076	9141677212	sharathyadavsss@gmail.com
68	BALAJI C	1KS16ME406	8123999340	balajic415@gmail.com
69	PRAVEEN KUMAR M	1KS16ME419	9880274493	praveenyadav1997.pk@gmail.com
70	CHANNAPPAGOUDA	3GU14ME016	7090964343	channugouda220@gmail.com

Head of the Department
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K.S. Institute of Technology
Bengaluru - 560 109.

K.S. INSTITUTE OF TECHNOLOGY, BENGALURU - 560109
DEPARTMENT OF MECHANICAL ENGINEERING
INDIVIDUAL TIME TABLE FOR THE YEAR 2019-20 (EVEN SEMESTER)

NAME : Mr. Parushuram .A. Kutakanakeri

Designation : Assistant Professor

W.E.F. : 06/2/2019

PERIOD	1	2	3	4		5	6	7
TIME/ DAY	8:30 -9:25	9:25 -10:20	10:35 - 11:30	11:30 - 12:25	12:25 - 1:30	1:30 -2:25	2:25 -3:20	3:20 - 4:15
MON	HT VI A			AE VI B	Lunch Break	HT LAB (VI A2)		
TUE			AE VI B					
WED				AE VI B				
THU	HT LAB (VI A3)					HT VI A	HT VI A	
FRI		HT VI A		AE VI B		HT VI A		
SAT								

	Subject Code	Subject Name	Sem	Section	Work Load
SUBJECT-1	15ME63	Heat Transfer	VI	A	9
SUBJECT-2	15ME655	Automobile Engineering	VI	B	
LAB-1	15MEl67	H T Lab	VI	A	6
PROJECT	15ME85	PROJECT PHASE II + SEMINAR	VIII	A&B	1.5
	-	Internship			3
ADDITIONAL WORK: NAAC Creteria -5, MENTORING, Class Teacher & OTHERS					
TOTAL LOAD= 19.5 Hrs/Week					

Time Table Co Ordinator

HOD
Head of the Department
Dept. of Mechanical Engg.
K.S. Institute of Technology
Bengaluru - 560 109

Principal
PRINCIPAL
K.S. INSTITUTE OF TECHNOLOGY
BENGALURU - 560 109

K. S. INSTITUTE OF TECHNOLOGY, BENGALURU - 560109
DEPARTMENT OF MECHANICAL ENGINEERING

VI SEMESTER TIME TABLE FOR THE YEAR 2019 (EVEN SEMESTER)

W.E.F: 06/02/2019
Section : VI A

Class Teacher : Mr.Parashuram A K
Class Room : NB LH 104

<table>
<tr><td>PERIOD</td><td>1</td><td>2</td><td rowspan="2">10:20 - 10.35</td><td>3</td><td>4</td><td rowspan="2">12:25 - 1:30</td><td>5</td><td>6</td><td>7</td></tr>
<tr><td>TIME/DAY</td><td>8:30 - 9:25</td><td>9:25 - 10:20</td><td>10:35 - 11:30</td><td>11:30 - 12:25</td><td>1:30 - 2:25</td><td>2:25 - 3:20</td><td>3:20 - 4:15</td></tr>
<tr><td>MON</td><td>HT
PAK</td><td>CIM
BKR</td><td rowspan="3">TEA BREAK</td><td>FEM
NB</td><td>MF/AE
MMR/AMR</td><td rowspan="6">LUNCH BREAK</td><td colspan="3">HT LAB(A2)/Mr. Parashuram A K
M&A LAB(A1)/ Mr. Ranganath N</td></tr>
<tr><td>TUE</td><td>DME-II
BB</td><td>DME-II
BB</td><td>MF/AE
MMR/AMR</td><td>IS/TQM
GS/NS</td><td>FEM
NB</td><td>FEM
NB</td><td>T</td></tr>
<tr><td>WED</td><td>DME-II
BB</td><td>DME-II
BB</td><td>CIM
BKR</td><td>MF/AE
MMR/AMR</td><td colspan="3">HT LAB(A1)/Mr. Prasad K
M&A LAB(A3)/ Mrs. Nirmala L</td></tr>
<tr><td>THU</td><td colspan="4">HT LAB(A3)/Mr. Parashuram A K
M&A LAB(A2)/ Mrs. Nirmala L</td><td>IS/TQM
GS/NS</td><td>HT
PAK</td><td>HT
PAK</td><td>CIM
BKR</td></tr>
<tr><td>FRI</td><td>CIM
BKR</td><td>HT
PAK</td><td></td><td>FEM
NB</td><td>MF/AE
MMR/AMR</td><td>HT
PAK</td><td>IS/TQM
GS/NS</td><td>IS/TQM
GS/NS</td></tr>
<tr><td>SAT</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Subject Code	Subject Name	Faculty Name
15ME61	Finite Element Analysis	Mr. Umashanakar M/ Mr. Nagabhushana M
15ME62	Computer Integrated Manufacturing	Mr. Bharath Kumar K R
15ME63	Heat Transfer	Mr. Parashuram A K
15ME64	Design of Machine Elements-II	Mr.Balaji.B
15ME653	Metal Forming	Mr. Mallikarjuna M R
15ME655	Automobile Engineering	Mr. Abhishek M R
15ME662	Industrial Safety	Mr. Gautham S
15ME664	Total Quality Management	Mrs. Sreesudha N
15MEL67	Heat Transfer Lab	Mr. Parashuram A K (A2,A3)/ Mr. K. Prasad (A1)
15MEL68	Modelling & Analysis lab	Mrs. Nirmala L (A2, A3) / Mr. Ranganath N (A1)

TIME TABLE CO- ORDINATOR

HEAD OF THE DEPARTMENT
Head of the Department
Dept. of Mechanical Engg.
K.S. Institute of Technology
Bengaluru - 560 109.

06/02/19
PRINCIPAL
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K.S. INSTITUTE OF TECHNOLOGY
BENGALURU - 560 109.

Heat Transfer

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Heat Transfer	15ME63	04	3-2-0	80	20	3Hrs

Pre-requisites: Basic and Applied Thermodynamics

Course learning objectives:

- Study the modes of heat transfer.
- Learn how to formulate and solve 1-D steady and unsteady heat conduction problems.
- Apply empirical correlations for fully-developed laminar, turbulent internal flows and external boundary layer convective flow problems.
- Study the basic principles of heat exchanger analysis and thermal design.
- Understand the principles of boiling and condensation including radiation heat transfer related engineering problems.

Module – I

Introductory concepts and definitions: Modes of heat transfer: Basic laws governing conduction, convection, and radiation heat transfer; Thermal conductivity; convective heat transfer coefficient; radiation heat transfer combined heat transfer mechanism, Types of boundary conditions. General Heat Conduction Equation: Derivation of the equation in (i) Cartesian, (ii) Polar and (iii) Spherical Co-ordinate Systems.

Steady-state one-dimensional heat conduction problems in Cartesian System: Steady-state one-dimensional heat conduction problems (i) with and without heat generation and (ii) with and without varying thermal conductivity - in Cartesian system with various possible boundary conditions, Thermal Resistances in Series and in Parallel. **8 Hours**

Module – II

Critical Thickness of Insulation: Concept, Derivation, Extended Surfaces or Fins: Classification, Straight Rectangular and Circular Fins, Temperature Distribution and Heat Transfer Calculations, Fin Efficiency and Effectiveness, Applications

Transient [Unsteady-state] heat conduction: Definition, Different cases - Negligible internal thermal resistance, negligible surface resistance, comparable internal thermal and surface resistance, Lumped body, Infinite Body and Semi-infinite Body, Numerical Problems, Heisler and Grober charts.

9 Hours

Module – III

Numerical Analysis of Heat Conduction: Introduction, one-dimensional steady conduction, one dimensional unsteady conduction, two-dimensional steady and unsteady conduction, the difference equation, boundary conditions, solution methods, cylindrical coordinates and irregular boundaries.

Thermal Radiation: Fundamental principles - Gray, White, Opaque, Transparent and Black bodies, Spectral emissive power, Wien's, Rayleigh-Jeans' and Planck's laws, Hemispherical Emissive Power, Stefan-Boltzmann law for the total emissive power of a black body, Emissivity and Kirchhoff's Laws, View factor, Net radiation exchange in a two-body enclosure, Typical examples for these enclosures, Radiation Shield.

9 Hours

Module – IV

Forced Convection: Boundary Layer Theory, Velocity and Thermal Boundary Layers, Prandtl number, Governing Equations – Continuity, Navier-Stokes and Energy equations, Boundary layer assumptions, Integral and Analytical solutions to above equations, Turbulent flow, Various empirical solutions, Forced convection flow over cylinders and spheres, Internal flows –laminar and turbulent flow solutions, Forced Convection Cooling of Electronic Devices.

Free convection: Laminar and Turbulent flows, Vertical Plates, Vertical Tubes and Horizontal Tubes, Empirical solutions.

8 Hours

Module – V

Heat Exchangers: Definition, Classification, applications, LMTD method, Effectiveness - NTU method, Analytical Methods, Fouling Factors, Chart Solution Procedures for solving Heat Exchanger problems: Correction Factor Charts and Effectiveness-NTU Charts, compact heat exchangers.

Heat Transfer with Phase Change: Introduction to boiling, pool boiling, Bubble Growth Mechanisms, Nucleate Pool Boiling, Critical Heat Flux in Nucleate Pool Boiling, Pool Film Boiling, Critical Heat Flux, Heat Transfer beyond the Critical Point, filmwise and dropwise Condensation, heat pipes, entrainment, wicking and boiling limitations. **9 Hours**

Course Outcomes

At the end of the course, the student will be able to:

- Understand the basic modes of heat transfer.
- Compute temperature distribution in steady-state and unsteady-state heat conduction
- Understand and interpret heat transfer through extended surfaces.
- Interpret and compute forced and free convective heat transfer.
- Explain the principles of radiation heat transfer and understand the numerical formula for heat conduction problems.
- Design heat exchangers using LMTD and NTU methods.

TEXT BOOKS:

1. Principals of heat transfer, Frank Kreith, Raj M. Manglik, Mark S. Bohn, Seventh Edition, Cengage learning, 2011.
2. Yunus A. Cengel - Heat transfer, a practical approach, Fifth edition,Tata Mc Graw Hill.

REFERENCE BOOKS:

1. Heat nd mass transfer, Kurt C, Rolle, second edition, Cengage learning.
2. Heat Transfer, M. Necati Ozisik, A Basic Approach, McGraw Hill, New York, 2005.
3. Fundamentals of Heat and Mass Transfer, Incropera, F. P. and De Witt, D. P., 5th Edition, John Wiley and Sons, New York, 2006.
4. Heat Transfer, Holman, J. P., 9th Edition, Tata McGraw Hill, New York, 2008.

E-Books/Web references:

1. A Text book of Heat Transfer, John H Lienhard, 4th Edition,
2. NPTEL Heat Transfer course for Mechanical Engineering, http://nptel.ac.in/courses/112101097/
3. Heat Transfer, Chris Long & Naser Sayma, Bookboon.com

MOOCs:

1. Fluid flow, Heat and Mass Transfer- http://ocw.tudelft.nl/courses/applied-earth-sciences/fluid-flow-heat-mass-transfer/course
2. Heat transfer course- https://legacy.saylor.org/me204/Intro/

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing at least one full question from each module.

KS INSTITUTE OF TECHNOLOGY BANGALORE

DEPARTMENT OF MECHANICAL ENGINEERING

Date:-6-02-2019

COURSE PLAN

Academic Year	**2018-2019**								
Batch	**2016-2020**								
Year/Semester/section	**III/VI/A**								
Course Component	**Professional core**								
Subject Code-Title	**15ME63-HEAT TRANSFER**								
No. of Students	**63**								
Schedule	**L**	**3**	**T**	**2**	**P**	**-**	**C**	**4**	
Name of the Instructor	**Mr.Parashuram.A.K**							**Dept**	**Mech**

Prerequisite Courses	Knowledge of Thermodynamics and Fluid Mechanics	
Course Objectives	Study the modes of heat transfer. • Learn how to formulate and solve 1-D steady and unsteady heat conduction problems. • Apply empirical correlations for fully-developed laminar, turbulent internal flows and external boundary layer convective flow problems. • Study the basic principles of heat exchanger analysis and thermal design. • Understand the principles of boiling and condensation including radiation heat transfer related engineering problems.	
Course Outcomes (Min 4 Max 6. Out of which one for content beyond syllabus)	CO1	Identify the three modes of heat transfer and construct conduction heat transfer equations for composite bodies make use of both sizing and rating methods
	CO2	Construct the fins to enhance heat transfer from a surface and solve for unsteady heat conduction rate.
	CO3	Select the type of correlation to be used suitably so as to experiment with convection heat transfer coefficient for various applications
	CO4	Utilize the methods, to find the exit temperature of fluid and size of heat exchangers, also identify the effect of cavitation and fouling due to boiling and condensation of fluid.
	CO5	Analyze two-dimensional heat conduction equations and examine the radiation heat transfer rate from black bodies, real surfaces and thermal shield
	CO6	Estimate all the three-heat transfer mechanisms using combined equations for heat transfer applications using CFD. **(Content beyond syllabus)**
Assessment pattern	• Internal Assessment1, Internal Assessment2 & Internal Assessment3 for 30 marks • Assignment for 20 marks Portions Covered: • Internal Test1- Unit 1 & First Half of 2^{nd} Unit. • Internal Test2- Second Half of 2^{nd} Unit & 3^{rd} Unit. • Internal Test3- 4^{th} Unit and First Half of 5^{th}Unit. • Model examination- All 5 units.	

Sl.No	Topic to be covered	Text/Ref Book Page No.	Mode of Delivery	Teaching Aid	No. of Periods	Cumulative No. of Periods	Proposed Date
MODULE IINTRODUCTORY CONCEPTS AND DEFINITIONS: MODES OF HEAT TRANSFER							
1.	Modes of heat transfer	T1(11-13)	L+D	BB	1	1	7/2/2019
2.		T1(13-20)	L+D	BB	1	2	8/2/2019
3.	Thermal conductivity; convective heat transfer coefficient;	T1(14)	L+D	BB+LAB	1	3	9/2/2019
4.	Radiation heat transfer combined heat transfer mechanism,	R2-13	L+D	BB	1	4	11/2/2019
5.	Types of boundary conditions.	R2-30	L+D	BB	1	5	12/2/2019
6.	General Heat Conduction Equation: Derivation of the equation in (i) Cartesian	T1(27-31)	L+D	BB	1	6	12/2/2019
7.	(ii)Polar and (iii) Spherical Co-ordinate Systems.	T1(32-37)	L+D		1	7	14/2/2019
8.	Steady-state one-dimensional heat conduction problems in Cartesian System: Steady-state one dimensional heat conduction problems (i) with and without heat generation	T1(38-39)	L+D	BB	1	8	15/2/2019
9.	With varying thermal conductivity - in Cartesian system with various possible boundary conditions,	T1(39-42)	L+D	BB	1	9	18/2/2019
10.	without varying thermal conductivity - in Cartesian system with various possible boundary conditions,	T1(42-43)	L+D	BB	1	10	19/2/2019
11.	Thermal Resistances in Series and in Parallel.	T1(42-43)	L+D	BB	1	11	19/2/2019
12.	Numericals	T1(44-45)	L+D	BB	1	12	21/2/2019
13.	Numericals	T1(45-47)	L+D	BB	1	13	22/2/2019
MODULE-2 TRANSIENT [UNSTEADY STATE] HEAT CONDUCTION							
14.	Definition, Different cases - Negligible internal thermal resistance	T1(290-310)	L+D	BB	1	14	
15.	Negligible surface resistance	R2-102	L+D	BB	1	15	
16.	comparable internal thermal and surface	R2-103	L+D	BB	1	16	

	resistance						
17.	Lumped body, Infinite Body and Semi-infinite Body	R2-120	L+D	BB+LAB	1	17	23/2/2019
18.	problems on lumped parametric analysis	R2-108	L+D	BB	1	18	23/2/2019
19.	Numerical Problems, Heisler and Grober charts.	R2-109	L+D	BB	1	19	26/2/2019
20.	Numericals on semi infinite solids	R2-110	L+D	BB	1	20	26/2/2019
	MODULE-3 THERMAL RADIATION						
21.	Fundamental principles - Gray, White, Opaque, Transparent and Black Bodies	T1(675-677)	L+D	BB	1	21	28/2/2019
22.	Spectral emissive power, Wien's, Rayleigh-Jeans' and Planck's laws	T1(678-681)	L+D	BB	1	22	1/3/2019
23.	Hemispherical Emissive Power, Stefan-Boltzmann law for the total emissive power of a black body	T1(678)	L+D	BB	1	23	5/3/2019
24.	Emissivity and Kirchhoff's Laws, View factor, Net radiation exchange in a two-body enclosure,	T1(689)	L+D	BB	1	24	5/3/2019
25.	Typical examples for these enclosures, Radiation Shield.	T1(742-745)	L+D	BB	1	25	7/3/2019
	TEST-1						12/3/2019
	MODULE 4 FORCED CONVECTION AND FREE CONVECTION						
26.	Boundary Layer Theory, Velocity and Thermal Boundary Layers	T1(374-398)	L+D	BB+LCD	1	26	8/3/2019
27.	Governing Equations – Continuity, Navier-Stokes and Energy equations	R2-253 R2-261	L+D	BB	1	27	14/3/2019
28.	Various empirical solutions, Forced convection flow over cylinders and spheres	T1(406-407)	L+D	BB	1	28	15/3/2019
29.	Internal flows –laminar and turbulent flow solutions	T1(407-410)	L+D	BB	1	29	18/3/2019
30.	Forced Convection Cooling of Electronic	T1(424-435)	L+D	BB	1	30	19/3/2019

	Devices.						
31.	Free convection: Laminar and Turbulent flows	W2-NPTEL	L+D	BB+LAB	1	31	19/3/2019
32.	Vertical Plates, Vertical Tubes	T1(425)	L+D	BB+LAB	1	32	21/3/2019
33.	Horizontal Tubes	T1(470)	L+D	BB	1	33	22/3/2019
34.	Empirical solutions	T1(471)	L+D	BB	1	34	25/3/2019
MODULE V HEAT EXCHANGERS							
35.	Heat Exchangers: Definition, Classification, applications	T1(574-580)	L+AV	BB+LCD	1	35	26/3/2019
36.	LMTD method, Effectiveness – NTU method,	T1(581-585)	L+D	BB+LAB	1	36	26/3/2019
37.	Analytical Methods, Fouling Factors	T1(586-587)	L+D	BB	1	37	28/3/2019
38.	Chart Solution Procedures for solving Heat Exchanger problems	T1(623-625)	L+D	BB	1	38	29/3/2019
39.	Correction Factor Charts and Effectiveness-NTU Charts, compact heat exchangers	T1(627-634)	L+D	BB	1	39	30/3/2019
40.	Numerical on LMTD method	T1(627-634)	L+D	BB	1	40	1/4/2019
41.	Numerical on NTU method	T1(627-634)	L+D	BB+LCD	1	41	2/4/2019
	MODULE 5 HEAT TRANSFER WITH PHSE CHANGE						
42.	Heat Transfer with Phase Change: Introduction to boiling, pool boiling	R2-476	L+D	BB	1	42	2/4/2019
43.	Bubble Growth Mechanisms, Nucleate Pool Boiling	R2-493	L+D	BB	1	43	4/4/2019
44.	Critical Heat Flux in Nucleate Pool Boiling, Pool Film Boiling.	T2-599	L+AV	BB+LAB	1	44	5/4/2019
45.	Critical Heat Flux, Heat Transfer beyond the Critical Point,	T2-603	L+D	BB	1	45	8/4/2019
46.	Film wise and drop wise Condensation, heat pipes, entrainment, wicking and boiling limitations	T2-612	L+D	BB	1	46	9/4/2019
47.	Numericals on condensation	T2-612	L+D	BB	1	47	9/4/2019

	MODULE 3 NUMERICAL ANALYSIS OF HEAT CONDUCTION						
48.	Introduction, one-dimensional steady conduction, one dimensional unsteady conduction,	T2-157	L+D	BB	1	49	12/4/2019
49.	two-dimensional steady and unsteady conduction	T1(271)	L+D	BB+LCD	1	50	13/4/2019
50.	The difference equation,	T1(272)	L+D	BB	1	51	13/4/2019
51.	Boundary conditions, Solution methods,	T1(278)	L+D	BB	1	52	15/4/2019
52.	Cylindrical coordinates and irregular boundaries	T1(318)	L+D	BB	1	53	16/4/2019
53.	Numericals	T1(318)	L+AV	BB	1	54	16/4/2019
	TEST-2						20/4/2019
	MODULE 2 CRITICAL THICKNESS OF INSULATION						
54.	Critical Thickness of Insulation: Concept, Derivation, Extended Surfaces or Fins	T1(142-145)	L+D	BB	1	55	23/4/2019
55.	Classification, Straight Rectangular and Circular Fins	T1(203-250)	L+D	BB+LCD	1	56	23/4/2019
56.	Temperature Distribution and Heat TransferCalculations	T1(207-209)	L+D	BB	1	57	25/4/2019
57.	Fin Efficiency and Effectiveness,	T1(210)	L+D	BB	1	58	26/4/2019
58.	Applications of fin	T1(211)	L+D	BB	1	59	30/4/2019
59.	Applications of fin	T1(210)	L+AV	BB	1	60	30/4/2019
60.	Revision	-	L+D	BB	1	61	2/5/2019
61.	Revision	-	L+D	BB	1	62	3/5/2019
62.	Revision	-	L+D	BB	1	63	6/5/2019
63.	Revision	-	L+D	BB	1	64	9/5/2019
64.	Revision	-	L+D	BB	1	65	10/5/2019
65.	**TEST-3**						23/5/2019
66.							
	Content Beyond Syllabus						
67.	**Beyond Syllabus:** Practical sessions and small projects on Heat transfer.	W2-NPTEL	L+I	LCD	1		

TEXT BOOKS:

T1: Heat and Mass Transfer,R K Rajput sixth edition2015,S chand publishing.
T2: Yunus A. Cengel - Heat transfer, a practical approach, Fifth edition,TataMcGraw Hill.
T3: Principals of heat transfer, Frank Kreith, Raj M. Manglik, Mark S. Bohn, Seventh Edition, Cengage learning, 2011.

REFERENCE BOOKS:

R1: Heat nd mass transfer, Kurt C, Rolle, second edition, Cengage learning.
R2: Heat Transfer, M. NecatiOzisik, A Basic Approach, McGraw Hill, New York, 2005.
R3: Fundamentals of Heat and Mass Transfer, Incropera, F. P. and De Witt, D. P., 5^{th} Edition, John Wiley and Sons, New York, 2006.
R4: Heat Transfer, Holman, J. P., 9th Edition, Tata McGraw Hill, New York, 2008.

E-Books/Web references:

W1: A Text book of Heat Transfer, John H Lienhard, 4th Edition,
W2: NPTEL Heat Transfer course for Mechanical Engineering,http://nptel.ac.in/courses/112101097/
W3: Heat Transfer, Chris Long &NaserSayma, Bookboon.com

MOOCs:

1. Fluid flow, Heat and Mass Transfer- http://ocw.tudelft.nl/courses/applied-earthsciences/fluid-flow-heat-mass-transfer/course
2. Heat transfer course- https://legacy.saylor.org/me204/Intro/

Signature of Course in charge **Signature of Module Coordinator** **Signature of HOD/ME**

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Signature of Chief Academic Coordinator **Signature of Principal**

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KSIT Bengaluru

DEPARTMENT OF MECHANICAL ENGINEERING

ASSIGNMENT QUESTIONS

Academic Year	2018-2019		
Batch	2016-2020		
Year/Semester/section	III/VI/ A&B		
Subject Code-Title	15ME63-HEAT TRANSFER		
Name of the Instructor	Parashuram A K Murulidhar K S	Dept	ME

Assignment No: 1 Total marks:20
Date of Issue: 05.03.19Date of Submission: 15.03.19

Sl.No	Assignment Questions	K Level	CO	Marks
1.	**Identify** the modes of heat transfer and also governing laws of heat transfer	Apply K3	CO1	2
2.	A furnace wall is made of inside silica brick (K=1.6 W/mK), outside magnetia brick (K=4.8 W/mk), 10 cm thick each. The inside and outside surfaces are exposed to fluid temperatures of 820^{0}C and 393 K respectively. **Find** the heat flow through the wall per m^2 per hour. Assume a contact resistance of 0.002 m^2/W. **Calculate** the temperatures and draw the temperature profile through the composite wall. The inside and outside heat transfer coefficients are 35W/m^2K and 0.012 kW/m^2K respectively.	Apply K3	CO1	2
3.	A surface plate of size 20cm x 20cm is inserted between two slabs. Slab A is 3cm thick (K = 50 W/mK) and slab B is 1.5cm thick (K=0.2 W/mK). The outside heat transfer coefficients on both sides of A and B are 200 and 50 W/m^2 K respectively. Temperature of surrounding air is 25^0 C. If the rating of heater is 1 kW, **Find** (i) Maximum temperature in the system (ii)Outer surface temperature of two slabs. Draw temperature profile.	Apply K3	CO1	2
4.	A furnace wall is made of 3lyers, 1st layer is of insulator brick of 12cm thickness (k=0.6W/mK) .The face is exposed to gases at 870^{0}C with convection coefficient of 110W/m^2K. it is covered with a 10cm thick layer of fire brick(k=0.8W/mK)with a contact resistance of 2.6X$10^{-4}$$m^2$K/W between 1st and 2nd layer the 3rd layer is plate of 10cm thickness(k=4W/mk)with a contact resistance between 2nd and 3rd layer of 1.5X$10^{-4}$$m^2$K/W. the plate is exposed to air at 30^{0}C with convection coefficient of 15W/m^2K.**Determine** the heat flow and overall heat transfer coeeficient.	Apply K3	CO1	2
5.	**Derive** an expression for 3D heat conduction equation for rectangular coordinate system also write fourier's,laplace and poison's equation.	Apply K3	CO1	2

6.	**Derive** an expression for temperature distribution,instantaneous transfer and total quantity of heat flow for lumped analysis at unsteady state heat transfer also write the significance of biot and fourier's number	Apply K3	CO2	2
7.	In a quenching process a copper plate 3mm thick is heated upto 400^{0}C and when exposed to an ambient temperature 25^{0}C with the convection coefficient of 28 W/m^{2}K, **Calculate** the time required to reach the temperature of 50^{0}C. Take thermo physical properties as C=380J/kgK, ρ=8800 kg/m^3 and k=385W/mK	Apply K3	CO2	2
8.	An egg with mean dia of 4cm is instantly at 25^{0}C.It is placed in the boiling water for 4minutes and found to be consumer taste .For how long similar egg for same consumer be boiled when taken from refrigerator at 2^{0}C. Use Lumped system analysis and thermophysical properties of egg is 12W/mK,h=125W/m^{2}K, C=2000J/kgK and ρ=1250kg/m^3	Apply K3	CO2	2
9.	**Make use of** the concept of radiation develop the equations for i)Stefan Boltzmann law ii) Kirchoffs Law iii) Plank,s Law iv) Wein's displacement law v) Radiation shield	Apply K3	CO4	2
10.	**Choose** the correct definition for i) Black body and gray body ii) Radiosity and Irradiation	Apply K3	CO4	2

Course In charge

HOD/ME

Head of the Department
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K.S INSTITUTE OF TECHNOLOGY
Bengaluru – 560109

Scheme & Solution of FIRST Assignment

Academic Year	2018-2019		
Batch	2016-2020		
Year/Semester/section	III/VI/ A&B		
Subject Code-Title	15ME63-HEAT TRANSFER		
Name of the Instructor	Parashuram A K Murulidhar K S	Dept	ME

Assignment No: 1 Total marks:20
Date of Issue: 05.03.19Date of Submission: 15.03.19

Question Number	Solution	Marks Allotted
1	Modes of heat transfer a) Conduction b) Convection c) Radiation Governing laws a) fourier's law of heat conduction b) Newton's law cooling for convection c) Stefan boltzman's law for radiation	2
2	Q = 2320.18 W, $T_1 = 753.64^0C$, $T_2 = 366.17^0C$, $T_3 = 361.53^0C$, $T_4 = 317.9^0C$	2
3	$Q = Q_1 + Q_2$, $Q_1 = 7.143\ T_2 - 178.56$, $Q_2 = 0.421\ T_2 - 10.53$. $T_2 = 157.29\ ^0C$. $Q_1 = 944.94$ W, $Q_2 = 55.06$ W	2
4	ΣR_{th}=0.426K/W, Q=1971.8 W,U=2.347W/m^{2}K	2
5	$\left(\frac{\partial^2 T}{\partial x^2}\right)+\left(\frac{\partial^2 T}{\partial y^2}\right)+\left(\frac{\partial^2 T}{\partial z^2}\right)+\left(\frac{Q_{gen}}{k}\right)=\left(\frac{1}{\alpha}\right)\left(\frac{\partial T}{\partial t}\right)$ Fourier's equation $\nabla^2 T = \left(\frac{1}{\alpha}\right)\left(\frac{\partial T}{\partial t}\right)$ Poisson's equation $\nabla^2 T + \left(\frac{Q_{gen}}{k}\right)=0$ Laplace equation$\nabla^2 T = 0$	2
6	$\frac{T - T_\infty}{T_0 - T_\infty} = e^{-B_i F_0}$ $Q_i=-hA_s(T_0-T_\infty)e^{-B_i F_0}$ $Q_T=\rho CV(T_0-T_\infty)\ (e^{-B_i F_0}-1)$	2
7	$L_c=1.5X10^{-3}$m,B_i=1.09 X10^{-4}, α=1.15 X10^{-4}m^2/s,t=486.43 sec(8.1minutes)	2
8	$L_c=6.667X10^{-3}$m,B_i=0.069, α=4.8 X10^{-6}m^2/s,F_0=25.89 ,T=87.43^{0}C, t=279 sec(t=4.66min)	2

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DEPARTMENT OF MECHANICAL ENGINEERING

ASSIGNMENT QUESTIONS

Academic Year	2018-2019		
Batch	2016-2020		
Year/Semester/section	III/VI/ A&B		
Subject Code-Title	15ME63-HEAT TRANSFER		
Name of the Instructor	Parashuram A K Murulidhar K S	Dept	ME

Assignment No: 1 **Total marks:20**

Date of Issue: 05.03.19 **Date of Submission: 15.03.19**

Sl.No	Assignment Questions	K Level	CO	Marks
1.	**Identify** the modes of heat transfer and also governing laws of heat transfer	Apply K3	CO1	2
2.	A furnace wall is made of inside silica brick (K=1.6 W/mK), outside magnetia brick (K=4.8 W/mk), 10 cm thick each. The inside and outside surfaces are exposed to fluid temperatures of 820^{0}C and 393 K respectively. **Find** the heat flow through the wall per m^2 per hour. Assume a contact resistance of 0.002 m^2/W. **Calculate** the temperatures and draw the temperature profile through the composite wall. The inside and outside heat transfer coefficients are 35W/m^{2}K and 0.012 kW/m^{2}K respectively.	Apply K3	CO1	2
3.	A surface plate of size 20cm x 20cm is inserted between two slabs. Slab A is 3cm thick (K = 50 W/mK) and slab B is 1.5cm thick (K=0.2 W/mK). The outside heat transfer coefficients on both sides of A and B are 200 and 50 W/m^2 K respectively. Temperature of surrounding air is 25^0 C. If the rating of heater is 1 kW, **Find** (i) Maximum temperature in the system (ii)Outer surface temperature of two slabs. Draw temperature profile.	Apply K3	CO1	2
4.	A furnace wall is made of 3lyers, 1st layer is of insulator brick of 12cm thickness (k=0.6W/mK) .The face is exposed to gases at 870^{0}C with convection coefficient of 110W/m^{2}K. it is covered with a 10cm thick layer of fire brick(k=0.8W/mK)with a contact resistance of 2.6X10^{-4}m^{2}K/W between 1st and 2nd layer the 3rd layer is plate of 10cm thickness(k=4W/mk)with a contact resistance between 2nd and 3rd layer of 1.5X10^{-4}m^{2}K/W. the plate is exposed to air at 30^{0}C with convection coefficient of 15W/m^{2}K.**Determine** the heat flow and overall heat transfer coeeficient.	Apply K3	CO1	2
5.	**Derive** an expression for 3D heat conduction equation for rectangular coordinate system also write fourier's,laplace and poison's equation.	Apply K3	CO1	2

6.	**Derive** an expression for temperature distribution,instantaneous transfer and total quantity of heat flow for lumped analysis at unsteady state heat transfer also write the significance of biot and fourier's number	Apply K3	CO2	2
7.	In a quenching process a copper plate 3mm thick is heated upto 400^0C and when exposed to an ambient temperature 25^0C with the convection coefficient of 28 W/m^2K, **Calculate** the time required to reach the temperature of 50^0C. Take thermo physical properties as C=380J/kgK, ρ=8800 kg/m^3 and k=385W/mK	Apply K3	CO2	2
8.	An egg with mean dia of 4cm is instantly at 25^0C.It is placed in the boiling water for 4minutes and found to be consumer taste .For how long similar egg for same consumer be boiled when taken from refrigerator at 2^0C. Use Lumped system analysis and thermophysical properties of egg is 12W/mK,h=125W/m^2K, C=2000J/kgK and ρ=1250kg/m^3	Apply K3	CO2	2
9.	**Make use of** the concept of radiation develop the equations for i)Stefan Boltzmann law ii) Kirchoffs Law iii) Plank,s Law iv) Wein's displacement law v) Radiation shield	Apply K3	CO4	2
10.	**Choose** the correct definition for i) Black body and gray body ii) Radiosity and Irradiation	Apply K3	CO4	2

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Scheme & Solution of FIRST Assignment

Academic Year	2018-2019		
Batch	2016-2020		
Year/Semester/section	III/VI/ A&B		
Subject Code-Title	15ME63-HEAT TRANSFER		
Name of the Instructor	Parashuram A K Murulidhar K S	Dept	ME

Assignment No: 1 Total marks:20
Date of Issue: 05.03.19Date of Submission: 15.03.19

Question Number	Solution	Marks Allotted
1	Modes of heat transfer a) Conduction b) Convection c) Radiation Governing laws a) fourier's law of heat conduction b) Newton's law cooling for convection c) Stefan boltzman's law for radiation	2
2	$Q = 2320.18$ W, $T_1 = 753.64^0$C, $T_2 = 366.17^0$C, $T_3 = 361.53^0$C, $T_4 = 317.9^0$C	2
3	$Q = Q_1 + Q_2$, $Q_1 = 7.143\ T_2 - 178.56$, $Q_2 = 0.421\ T_2 - 10.53$. $T_2 = 157.29\ ^0$C. $Q_1 = 944.94$ W, $Q_2 = 55.06$ W	2
4	ΣR_{th}=0.426K/W, Q=1971.8 W,U=2.347W/m^2K	2
5	$\left(\frac{\partial^2 T}{\partial x^2}\right) + \left(\frac{\partial^2 T}{\partial y^2}\right) + \left(\frac{\partial^2 T}{\partial z^2}\right) + \left(\frac{Q_{gen}}{k}\right) = \left(\frac{1}{\alpha}\right)\left(\frac{\partial T}{\partial t}\right)$ Fourier's equation $\nabla^2 T = \left(\frac{1}{\alpha}\right)\left(\frac{\partial T}{\partial t}\right)$ Poisson's equation $\nabla^2 T + \left(\frac{Q_{gen}}{k}\right) = 0$ Laplace equation $\nabla^2 T = 0$	2
6	$\frac{T - T_\infty}{T_0 - T_\infty} = e^{-B_i F_0}$ $Q_i = -hA_s(T_0 - T_\infty)e^{-B_i F_0}$ $Q_T = \rho CV(T_0 - T_\infty)\ (e^{-B_i F_0} - 1)$	2
7	$L_c = 1.5X10^{-3}$m, $B_i = 1.09\ X10^{-4}$, $\alpha = 1.15\ X10^{-4} m^2/s$, t=486.43 sec(8.1minutes)	2
8	$L_c = 6.667X10^{-3}$m, $B_i = 0.069$, $\alpha = 4.8\ X10^{-6} m^2/s$, $F_0 = 25.89$,$T = 87.43^0$C, t=279 sec(t=4.66min)	2

9	Equations for i)Stefan Boltzmann law ii) Kirchoffs Law iii) Plank,s Law iv) Wein's displacement law v) Radiation shield	2
10	Definition for i) Black body and gray body ii) Radiosity and Irradiation	2

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DEPARTMENT OF MECHANICAL ENGINEERING

ASSIGNMENT QUESTIONS

Academic Year	**2018-2019**		
Batch	**2015-2019**		
Year/Semester/section	**III/VI/A**		
Subject Code-Title	**15ME63-HEAT TRANSFER**		
Name of the Instructor	**Mr.Parashuram A K** **Mr. Murulidhar K S**	**Dept**	**ME**

Assignment No: 2 **Total marks:20**

Date of Issue:8/4/2019 **Date of Submission: 16/4/2019**

Sl.No	Assignment Questions	K Level	CO	Marks
1.	A 50mm thick iron plate is initially at 225^0C its both surfaces are suddenly exposed to environment at 25^0C with convection coefficient of $500W/m^2K$ calculate : a) center temperature 2min after start of exposer b) calculate temperature at a depth of 10 mm from the surface after 2 min of exposer c) calculate energy removed from plate per square meter during this period take thermo physical properties of iron plate as K= 60 W/mK, $\rho=7850Kg/m^3$, Cp=460J/kg, $\alpha=1.6x10^{-5}$ m^2/s.	Apply K3	CO2	2
2.	A iron sphere of diameter of 5 cm is initially at uniform temperature of 225^0C it is suddenly exposed to an ambient air at 25^0C with convection coefficient of $500W/m^2K$ a) calculate center temperature 2 min after start of exposer b) calculate the temperature at a depth of 1 cm from the surface after 2 min after exposer c) calculate energy removed from sphere during this period Take thermo physical properties of iron plate as K= 60 W/mK,$\rho=7850Kg/m^3$, Cp= 460J/KgK , $\alpha=1.6x10^{-5}$ m^2/s.	Apply K3	CO2	2
3.	With sketches, explain the velocity (Hydrodynamic) boundary layer and thermal boundary layer thickness for a flow over the flat plate.	Apply K3	CO3	2
4.	Using Buckingham theorem, obtain a relationship between Nu, Re and Pr For forced convection heat transfer.	Apply K3	CO3	2
5.	Explain physical significance of ,i) Grashoff number ii) Prandtl number iii) Nusselt number iv) Reynolds number	Apply K3	CO3	2

6.	Air at 20^0C at a pressure of 1 bar is flowing over flat plate at a velocity of 3 m/s if the plate is 280mm wide and at 60^0C calculate fallowing at x= 280 mm. a) Boundary layer thickness b) local friction coefficient c) Average friction coefficient d) shear stress due to friction e) thickness of thermal boundary layer f) local convective heat transfer coefficient g) Average convective heat transfer coefficient h) heat transfer by convection i) Total drag force on plate .	Apply K3	CO3	2
7.	Air at 25^0C flows over flat plate at 2.5m/s. the plate measures (60cmx30cm) & is maintained at uniform temperature of 90^0C. Calculate heat loss from plate. if air flow parallel to 60 cm side . How this heat loss would be affected if the flow of air is made parallel to 30cm.	Apply K3	CO3	2
8.	When 0.9 kg of water /min is passed through a tube of 20 mm diameter it is found to be heated from 20^0C to 50^0C the heating is accomplished by condensing steam on surface of tube & subsequently the surface temperature of tube is maintained at 85^0C. Determine length of tube required for fully developed flow.	Apply K3	CO5	2
9.	Water is heated while flowing through (1.5cm x3.5cm) rectangular cross section tube at a velocity 0f 1.2 m/s the entry of water is 40^0C & tube wall maintained at 85^0C determine the length of the tube required to rise the temperature of water to 70^0C. Properties of water at 55^0C are ρ= 985.5kg/m3, γ= 0.517×10^{-6} m^2/s, K=0.654 W/mK , Cp=4.18kJ/kgK, Pr=3.26.	Apply K3	CO5	2
10.	Assuming that a man can be represented by a cylinder 30 cm diameter & 1.7 m high with surface temperature of 30^0C calculate heat he would loses, while standing in 36km/hr wind at 10^0C.	Apply K3	CO5	2

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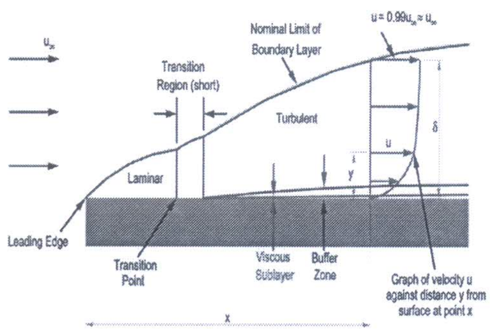
Scheme & Solution of second Assignment

Academic Year	2018-2019		
Batch	2016-2020		
Year/Semester/section	III/VI/ A&B		
Subject Code-Title	15ME63-HEAT TRANSFER		
Name of the Instructor	Parashuram A K Murulidhar K S	Dept	ME

Assignment No: 1 **Total marks:20**

Date of Issue: 16.04.19 **Date of Submission: 16.04.19**

Question Number	Solution	Marks Allotted
1	Tcenter=141^0C , $T_{(x,t)}=137.7^0C$, Q=14.4MW	2
2	Tcenter=61^0C , $T_{(r,t)}=59.56^0C$,Q=28.36kJ	2
3	Explanation of velocity (Hydrodynamic) boundary layer and thermal boundary layer thickness 	2
4	Using Buckingham theorem, prove that Nu=(Re * Pr)	2
5	significance of dimesionless no i) Grashoff number ii) Prandtl number iii) Nusselt number iv) Reynolds number	2

6	a)δh_x=6.29*10^{-3}m, b)C_{fx}=2.88*10^{-3}, c)$C_{fl\ x}$=5.96*10^{-3}, d)hshear stress=0.03N/m^2, e) δt_x =7.12*10^{-3} f) h_x=6.45w/m^2K g) h=12.9 w/m^2K h)Q=40.45 i)FD= 2.35*10^{-3}N	
7	Q1=100.8 W Q2=142.26W Increase in heat loss =Q2-Q1=41.3W	2
8	h=114.92 w/m^2K, Q=1880.1W, ,L=5.37m	2
9	Dh=0.021m, h=6466.89 w/m^2K, Q=77.856kW,L=4.41m	2
10	Nu=436.8 h=37.7 w/m^2K ,Q=1208.22	2

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SET A

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I SESSIONAL TEST QUESTION PAPER 2018 – 19 EVEN SEMESTER

USN										

Degree	:	B.E	Semester :	VI A & B
Branch	:	Mechanical Engineering	Subject Code :	15ME63
Subject Title	:	Heat Transfer	Date :	12/03/2019
Duration	:	90 Minutes	Max Marks :	30

Note: Answer ONE full question from each part.

Q No.	Question	Marks	K Level	CO mapping
	PART-A			
1(a)	**Derive** the general three-dimensional conduction equation in Cartesian coordinates and state the assumptions made	5	Apply K3	CO1
(b)	A square plate heater of size 20cm x 20cm is inserted between two slabs. Slab A is 3cm thick (K = 50 W/mK) and slab B is 1.5cm thick (K=0.2 W/mK). The outside heat transfer coefficients on both sides of A and B are 200 and 50 W/m^2 K respectively. Temperature of surrounding air is 25^0 C. If the rating of heater is 1 kW, **Find** (i) Maximum temperature in the system (ii)Outer surface temperature of two slabs. Draw temperature profile.	5	Apply K3	CO1
(c)	**Make use of** the concept of radiation develop the equations for i)Stefan Boltzmann law ii) Kirchoffs Law iii) Plank,s Law	5	Apply K3	CO4
	OR			
2(a)	**Identify** the modes of heat transfer and also governing laws of heat transfer.	5	Apply K3	CO1
(b)	A furnace wall is made of 3lyers, 1^{st} layer is of insulator brick of 12cm thickness (k=0.6W/mK) .The face is exposed to gases at 870^0C with convection coefficient of $110W/m^2K$. it is covered with a 10cm thick layer of fire brick(k=0.8W/mK)with a contact resistance of $2.6X10^{-4}m^2K/W$ between 1^{st} and 2^{nd} layer the 3^{rd} layer is plate of 10cm thickness(k=4W/mk)with a contact resistance between 2^{nd} and 3^{rd} layer of $1.5X10^{-4}m^2K/W$. the plate is exposed to air at 30^0C with convection coefficient of $15W/m^2K$.**Determine** the heat flow and overall heat transfer coefficient.	5	Apply K3	CO1

SET A

(c)	**Choose** the correct definition for i) Black body and gray body ii) Radiosity and Irradiation	5	Apply K3	CO4
	PART-B			
3(a)	A plane wall confined to region **0≤ x ≤ L** is subjected to heat supply at rate of q_o **w/m²** at the boundary surface **x=0** & dissipates heat by convection with heat transfer coefficient h w/m^2C in to the ambient air at temperature T∞ from the boundary surface at **x=L write** the mathematical formulation of this conduction problem.	5	Apply K3	CO1
(b)	**Explain** briefly i) thermal conductivity ii) thermal diffusivity iii) Overall heat transfer coefficient.	5	Apply K3	CO1
(c)	**Derive** an expression for temperature distribution of lumped parametric analysis	5	Apply K3	CO2
	OR			
4(a)	**What** do you mean by initial conditions and boundary conditions of I, II, III kind?	5	Apply K3	CO1
(b)	A 600 mm outer diameter sphere storing liquid is provided with two insulating layer . a high temperature insulation of conductivity 0.35 W/mK and low temperature insulation of thermal conductivity 0.07 W/mK. The thickness of former is is 100mm. the temperature drop across high temperature insulation is 2.5 times that across low temperature insulation **calculate** the thickness of latter.	5	Apply K3	CO1
(c)	An egg with mean dia of 4cm is instantly at 25^0C.It is placed in the boiling water for 4minutes and found to be consumer taste .For **how long** similar egg for same consumer be boiled when taken from refrigerator at 2^0C. Use Lumped system analysis and thermo physical properties of egg is 12W/mK,h=125W/m²K, C=2000J/kgK and ρ=1250kg/m³	5	Apply K3	CO2

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I SESSIONAL TEST QUESTION PAPER 2018 – 19 EVEN SEMESTER

SCHEME AND SOLUTION

Degree	:	**B.E**	**Semester**	:	**VI A&B**
Branch	:	**Mechanical**	**Course Code**	:	**15ME63**
Course Title	:	**Heat Transfer**	**Max Marks**	:	**30**

Q.NO.	POINTS	MARKS
1) a)	$\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2} + \frac{\partial^2 T}{\partial z^2} + \frac{Q_{gen}}{k} = \frac{1}{\alpha}\frac{\partial T}{\partial t}$ Fourier's equation $\nabla^2 T = \frac{1}{\alpha}\frac{\partial T}{\partial t}$ Poisson's equation $\nabla^2 T + \frac{Q_{gen}}{k} = 0$ Laplace equation $\nabla^2 T = 0$	3 + 2 = 5
b)	$Q = Q_1 + Q_2$, $Q_1 = 7.143\ T_2 - 178.56$, $Q_2 = 0.421\ T_2 - 10.53$. $T_2 = 157.29\ ^oC$. $Q_1 = 944.94$ W, $Q_2 = 55.06$ W	2 + 3 = 5
c)	Equations for i)Stefan Boltzmann law=$Q=\sigma\varepsilon A(T_1^4-T_2^4)$ ii) Kirchoffs Law=$E=\alpha$ iii) Plank,s Law=$(E_\lambda)_b=\frac{C_1\lambda^5}{[e^{c_2/\lambda T}-1]}$	2 + 3 = 5
2) a)	Modes of heat transfer a) Conduction b) Convection c) Radiation Governing laws a) fourier's law of heat conduction b) Newton's law cooling for convection c) Stefan boltzman's law for radiation	2 + 3 = 5
b)	$\Sigma R_{th}=0.426$K/W, Q=1971.8 W,U=2.347W/m2K	2 + 3 = 5
c)	Definition for i) Black body and gray body ii) Radiosity and Irradiation	2.5 + 2.5 = 5

3) a)	Specify the boundary conditions on plane wall At x= $q_0= -k\frac{dT}{dx}$ At x=l $h[T_\infty - T_{(x,t)}] = +k\frac{dT}{dx}$	2, 3 } 5
b)	Explanation of i) thermal conductivity ii) thermal diffusivity iii) Overall heat transfer coefficient.	2, 3 } 5
c)	Derivation of lumped parametric system $\frac{(T-T\infty)}{(T0-T\infty\_)}$=e$-BiF0$	2, 3 } 5
4 a)	Explanation of a) Temperature boundary condition b) heat flux boundary condition c) convective Boundary condition	3, 2 } 5
b)	r_3= 0.411m thickness of latter= 0.011m =11mm	2, 3 } 5
c)	L_c=6.667X10-3m,B_i=0.069, α=4.8 X10-6m2/s,F_0=25.89 ,T=87.430C, t=279 sec(t=4.66min)	2, 3 } 5

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SET B

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I SESSIONAL TEST QUESTION PAPER 2018 – 19 EVEN SEMESTER

USN										

Degree	:	**B.E**	**Semester**	:	**VI A & B**
Branch	:	**Mechanical Engineering**	**Subject Code**	:	**15ME63**
Subject Title	:	**Heat Transfer**	**Date**	:	**12/03/2019**
Duration	:	**90 Minutes**	**Max Marks**	:	**30**

Note: Answer ONE full question from each part.

Q No.	Question	Marks	K Level	CO mapping
	PART-A			
1(a)	**Identify** the modes of heat transfer and also governing laws of heat transfer.	5	Apply K3	CO1
(b)	A furnace wall is made of 3lyers, 1st layer is of insulator brick of 12cm thickness (k=0.6W/mK) .The face is exposed to gases at 870^{0}C with convection coefficient of 110W/m^{2}K. it is covered with a 10cm thick layer of fire brick(k=0.8W/mK)with a contact resistance of $2.6X10^{-4}$m^{2}K/W between 1st and 2nd layer the 3rd layer is plate of 10cm thickness(k=4W/mk)with a contact resistance between 2nd and 3rd layer of $1.5X10^{-4}$m^{2}K/W. the plate is exposed to air at 30^{0}C with convection coefficient of 15W/m^{2}K.**Determine** the heat flow and overall heat transfer coefficient.	5	Apply K3	CO1
	Choose the correct definition for i) Black body and gray body ii) Radiosity and Irradiation	5	Apply K3	CO4
	OR			
2(a)	**Derive** the general three-dimensional conduction equation in Cartesian coordinates and state the assumptions made	5	Apply K3	CO1
(b)	A square plate heater of size 20cm x 20cm is inserted between two slabs. Slab A is 3cm thick (K = 50 W/mK) and slab B is 1.5cm thick (K=0.2 W/mK). The outside heat transfer coefficients on both sides of A and B are 200 and 50 W/m^2 K respectively. Temperature of surrounding air is 25^0 C. If the rating of heater is 1 kW, **Find** (i) Maximum temperature in the system (ii)Outer surface temperature of two slabs. Draw temperature profile.	5	Apply K3	CO1

SET B

(c)	**Make use of** the concept of radiation develop the equations for i)Stefan Boltzmann law ii) Kirchoffs Law iii) Plank,s Law	5	Apply K3	CO4
PART-B				
3(a)	**What** do you mean by initial conditions and boundary conditions of I, II, III kind?	5	Apply K3	CO1
(b)	A 600 mm outer diameter sphere storing liquid is provided with two insulating layer . a high temperature insulation of conductivity 0.35 W/mK and low temperature insulation of thermal conductivity 0.07 W/mK. The thickness of former is is 100mm. the temperature drop across high temperature insulation is 2.5 times that across low temperature insulation **calculate** the thickness of latter.	5	Apply K3	CO1
(c)	An egg with mean dia of 4cm is instantly at 25^0C.It is placed in the boiling water for 4minutes and found to be consumer taste .For **how long** similar egg for same consumer be boiled when taken from refrigerator at 2^0C. Use Lumped system analysis and thermo physical properties of egg is 12W/mK,h=125W/m^2K, C=2000J/kgK and ρ=1250kg/m^3	5	Apply K3	CO2
OR				
4(a)	A plane wall confined to region **0≤ x ≤ L** is subjected to heat supply at rate of q_o **w/m^2** at the boundary surface **x=0 &** dissipates heat by convection with heat transfer coefficient h w/m^2C in to the ambient air at temperature T∞ from the boundary surface at **x=L write** the mathematical formulation of this conduction problem.	5	Apply K3	CO1
(b)	**Explain** briefly i) thermal conductivity ii) thermal diffusivity iii) Overall heat transfer coefficient.	5	Apply K3	CO1
	Derive an expression for temperature distribution of lumped parametric analysis	5	Apply K3	CO2

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Set B

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I SESSIONAL TEST QUESTION PAPER 2018 – 19 EVEN SEMESTER

SCHEME AND SOLUTION

Degree : **B.E**		**Semester** :	**VI A&B**
Branch : **Mechanical**		**Course Code** :	**15ME63**
Course Title : **Heat Transfer**		**Max Marks** :	**30**

Q.NO.	POINTS	MARKS
1) a)	Modes of heat transfer a) Conduction b) Convection c) Radiation Governing laws a) Fourier's law of heat conduction b) Newton's law cooling for convection c) Stefan Boltzmann's law for radiation	3, 2 } 5
b)	ΣR_{th}=0.426K/W, Q=1971.8 W, U=2.347W/m2K	2, 3 } 5
c)	Definition for i) Black body and gray body ii) Radiosity and Irradiation	2.5, 2.5 } 5
2) a)	$\frac{\partial^2 T}{\partial x^2}+\frac{\partial^2 T}{\partial y^2}+\frac{\partial^2 T}{\partial z^2}+\frac{Q_{gen}}{k}=\frac{1}{\alpha}\frac{\partial T}{\partial t}$ Fourier's equation $\nabla^2 T=\frac{1}{\alpha}\frac{\partial T}{\partial t}$ Poisson's equation $\nabla^2 T+\frac{Q_{gen}}{k}=0$ Laplace equation $\nabla^2 T=0$	2, 3 } 5
b)	$Q = Q_1 + Q_2$, $Q_1 = 7.143\ T_2 - 178.56$, $Q_2 = 0.421\ T_2 - 10.53$. $T_2 = 157.29\ ^{o}C$. $Q_1 = 944.94$ W, $Q_2 = 55.06$ W	2, 3 } 5
c)	Equations for i) Stefan Boltzmann law=$Q=\sigma\varepsilon A(T_1^4-T_2^4)$ ii) Kirchhoff's Law=$E=\alpha$ iii) Planck's Law=$(E_\lambda)_b=\frac{C_1\lambda^{-5}}{[e^{C_2/\lambda T}-1]}$	2, 3 } 5

3) a)	Explanation of a) Temperature boundary condition b) heat flux boundary condition c) convective Boundary condition	2, 3 → 5
b)	r_3= 0.411m thickness of latter= 0.011m =11mm	2, 3 → 5
c)	L_c=6.667X10-3m, B_i=0.069, α=4.8 X10-6m2/s, F_o=25.89 ,T=87.43oC, t=279 sec(t=4.66min)	2, 3 → 5
4 a)	Specify the boundary conditions on plane wall At x= $q_0 = -k\frac{dT}{dx}$ At x=l $h[T_\infty - T_{(x,t)}] = +k\frac{dT}{dx}$	3, 2 → 5
b)	Explanation of i) thermal conductivity ii) thermal diffusivity iii) Overall heat transfer coefficient.	2, 3 → 5
c)	Derivation of lumped parametric system $\frac{(T - T\infty)}{(T0 - T\infty\_)} = e - BiF0$	2, 3 → 5

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II SESSIONAL TEST QUESTION PAPER 2018 – 19 EVEN SEMESTER

SET – A

USN | | | | | | | | | | |

Degree	:	B.E	Semester	:	VI A & B
Branch	:	Mechanical Engineering	Course Code	:	15ME63
Course Title	:	HEAT TRANSFER	Date	:	16/4/2019
Duration	:	90 Minutes	Max Marks	:	30

Note: Answer ONE full question from each part.

Q No.	Question	Marks	CO mapping	K-Level
	PART-A			
1(a)	**Write a note on** use of heisler's chart in the unsteady state heat transfer	5	CO2	Understand K2
(b)	A 50mm thick iron plate is initially at 225^0C its both surfaces are suddenly exposed to environment at 25^0C with convection coefficient of $500 W/m^2K$ **calculate** : a) center temperature 2min after start of exposure b) calculate temperature at a depth of 10 mm from the surface after 2 min of exposure c) **calculate** energy removed from plate per square meter during this period take thermo physical properties of iron plate as K= 60 W/mK, $\rho=7850 Kg/m^3$, Cp=460J/kg, $\alpha=1.6x10^{-5} m^2/s$.	5	CO2	Apply K3
(c)	A steel cylinder 20 cm diameter is initially heated to 980^0C its then quenched in oil bath at 380^0C with convection coefficient of $568 W/m^2K$ **.calculate** time required cylinder center to reach a temperature of 260^0C properties of steel are K= 16 W/mK ,$\rho=7816 Kg/m^3$, Cp= 460J/KgK , $\alpha=4.4 x10^{-6} m^2/s$.	5	CO2	Apply K3
	OR			
2(a)	**Write a note on** semi infinite solid	5	CO2	Understand K2
(b)	A iron sphere of diameter of 5 cm is initially at uniform temperature of 225^0C it is suddenly exposed to an ambient air at 25^0C with convection coefficient of $500 W/m^2K$ a) **calculate** center temperature 2 min after start of exposer b) calculate the temperature at a depth of 1 cm from the surface after 2 min after exposer c) calculate energy removed from sphere during this period Take thermo physical properties of iron plate as K= 60 W/mK,$\rho=7850 Kg/m^3$, Cp= 460J/KgK , $\alpha=1.6x10^{-5} m^2/s$.	5	CO2	Apply K3

(c)	Water pipes are to be buried underground in a wet soil (α=1.6x10^{-5} m^2/hr) which is initially at 4.5^{0}C .the soil surface temperature suddenly drops to -5^{0}C and remains at this value for10 hours. **Calculate** the minimum depth at which the pipes are laid if the surrounding soil temperature is to be maintained above 0^{0}C .the soil may be considered as semi-infinite solid.	5	CO2	Apply K3
PART-B				
3 (a)	Using Buckingham π-theorem, **obtain** a relationship between Nu, Re and Pr For forced convection heat transfer.	5	CO3	Apply K3
(b)	When 0.9 kg of water /min is passed through a tube of 20 mm diameter it is found to be heated from 20^{0}C to 50^{0}C the heating is accomplished by condensing steam on surface of tube & subsequently the surface temperature of tube is maintained at 85^{0}C. **Determine** length of tube required for fully developed flow.	5	CO3	Apply K3
(c)	**Derive** an expression for critical thickness of insulation for cylindrical surface.	5	CO5	Apply K3
OR				
4(a)	With sketches, **explain** the velocity (Hydrodynamic) boundary layer and thermal boundary layer thickness for a flow over the flat plate.	5	CO3	Understand K2
(b)	Air at 20^{0}C at a pressure of 1 bar is flowing over flat plate at a velocity of 3 m/s if the plate is 280mm wide and at 60^{0}C **calculate** fallowing at x= 280 mm. a) Boundary layer thickness b) b)thickness of thermal boundary layer c) local friction coefficient layer d) local convective heat transfer coefficient e) Average convective heat transfer coefficient f) heat transfer by convection.	5	CO3	Apply K3
(c)	It is desired to increase the heat distribution on the surface of an electronic device of shape of 5 mm radius exposed to convection with h=10 w/m^2k by encasing in transparent spherical sheath of k=0.04 w/m k **determine** diameter of sheath for maximum heat flow for temperature drop of 120^{0}C from device surface determine heat flow for bare & sheathed device.	5	CO5	Apply K3

Signature of course incharge

Signature of HOD/ME 9/4/19

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Set A

K.S. INSTITUTE OF TECHNOLOGY, BANGALORE - 560109

II SESSIONAL TEST QUESTION PAPER 2018 – 19 EVEN SEMESTER

SCHEME AND SOLUTION

Degree : B.E
Branch : Mechanical
Course Title : Heat Transfer

Semester : VI
Course Code : 15ME63
Max Marks : 30

Q.NO.	POINTS	MARKS
1) a)	short notes on heisler's chart	5
b)	Tcenter=141^{0}C , $T_{(x,t)}$ =137.7^{0}C , Q=14.4MW	2, 3 } 5
c)	F_0=0.58, t =1318Sec	2, 3 } 5
2) a)	Write short notes on semi infinite solids	2, 3 } 5
b)	Tcenter=61^{0}C , $T_{(r,t)}$ =59.56^{0}C ,Q=28.36kJ	2, 3 } 5
c)	Z=0.5, x=0.0167m	2, 3 } 5

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II SESSIONAL TEST QUESTION PAPER 2018 – 19 EVEN SEMESTER

SCHEME AND SOLUTION

Degree	:	B.E	Semester	:	VI
Branch	:	Mechanical	Course Code	:	15ME63
Course Title	:	Heat Transfer	Max Marks	:	30

Q.NO.	POINTS	MARKS
1) a)	short notes on heisler's chart	5
b)	$T_{center}=141^0C$, $T_{(x,t)}=137.7^0C$, Q=14.4MW	2 + 3 = 5
c)	$F_0=0.58$, t =1318Sec	2 + 3 = 5
2) a)	Write short notes on semi infinite solids	2 + 3 = 5
b)	$T_{center}=61^0C$, $T_{(r,t)}=59.56^0C$,Q=28.36kJ	2 + 3 = 5
c)	Z=0.5, x=0.0167m	2 + 3 = 5

K.S. INSTITUTE OF TECHNOLOGY, BANGALORE - 560109

II SESSIONAL TEST QUESTION PAPER 2018 – 19 EVEN SEMESTER

SET – B

USN										

Degree	:	B.E	Semester	:	VI A & B
Branch	:	Mechanical Engineering	Course Code	:	15ME63
Course Title	:	Heat Transfer	Date	:	16/4/2019
Duration	:	90 Minutes	Max Marks	:	30

Note: Answer ONE full question from each part.

Q No.	Question	Marks	CO mapping	K-Level
	PART-A			
1(a)	**Write a note on** semi infinite solid	5	CO2	Understand K2
(b)	A iron sphere of diameter of 5 cm is initially at uniform temperature of 225^0C it is suddenly exposed to an ambient air at 25^0C with convection coefficient of $500W/m^2K$ a) **calculate** center temperature 2 min after start of exposure b) calculate the temperature at a depth of 1 cm from the surface after 2 min after exposure c) calculate energy removed from sphere during this period Take thermo physical properties of iron plate as K= 60 W/mK,ρ=7850Kg/m^3, Cp= 460J/KgK , $\alpha=1.6x10^{-5}$ m^2/s.	5	CO2	Apply K3
(c)	Water pipes are to be buried underground in a wet soil ($\alpha=1.6x10^{-5}$ m^2/hr) which is initially at 4.5^0C .the soil surface temperature suddenly drops to -5^0C and remains at this value for10 hours. **Calculate** the minimum depth at which the pipes are laid if the surrounding soil temperature is to be maintained above 0^0C .the soil may be considered as semi-infinite solid.	5	CO2	Apply K3
	OR			
2(a)	**Write a note on** use of heisler's chart in the unsteady state heat transfer	5	CO2	Understand K2
(b)	A 50mm thick iron plate is initially at 225^0C its both surfaces are suddenly exposed to environment at 25^0C with convection coefficient of $500W/m^2K$ **calculate** : a) center temperature 2min after start of exposer b) calculate temperature at a depth of 10 mm from the surface after 2 min of exposer c) **calculate** energy removed from plate per square meter during this period take thermo physical properties of iron plate as K= 60 W/mK, ρ=7850Kg/m^3, Cp=460J/kg, $\alpha=1.6x10^{-5}$ m^2/s.	5	CO2	Apply K3

(c)	A steel cylinder 20 cm diameter is initially heated to 980^0C its then quenched in oil bath at 380^0C with convection coefficient of $568 W/m^2K$.**calculate** time required cylinder center to reach a temperature of 260^0C properties of steel are K= 16 W/mK ,ρ=7816Kg/m^3, Cp= 460J/KgK , α=4.4 x10^{-6} m^2/s.	5	CO2	Apply K3
	PART-B			
3(a)	**Explain** physical significance of , i) Grashoff number ii) Prandtl number iii) Nusselt number iv) Reynolds number v) Stanton number	5	CO3	Understand K2
(b)	Air at 20^0C at a pressure of 1 bar is flowing over flat plate at a velocity of 3 m/s if the plate is 280mm wide and at 60^0C **calculate** fallowing at x= 280 mm. a) Boundary layer thickness b) b)thickness of thermal boundary layer c) local friction coefficient layer d) local convective heat transfer coefficient e) Average convective heat transfer coefficient f) heat transfer by convection	5	CO3	Apply K3
(c)	It is desired to increase the heat distribution on the surface of an electronic device of shape of 5 mm radius exposed to convection with h=10 w/m^2k by encasing in transparent spherical sheath of k=0.04 w/m k **determine** diameter of sheath for maximum heat flow for temperature drop of 120^0C from device surface **determine** heat flow for bare & sheathed device	5	CO5	Apply K3
	OR			
4(a)	Using Buckingham π-theorem, **obtain** a relationship between Nu, Re and Pr For forced convection heat transfer.	5	CO3	Apply K3
(b)	When 0.9 kg of water /min is passed through a tube of 20 mm diameter it is found to be heated from 20^0C to 50^0C the heating is accomplished by condensing steam on surface of tube & subsequently the surface temperature of tube is maintained at 85^0C. **Determine** length of tube required for fully developed flow.	5	CO3	Apply K3
(c)	**Derive** an expression for critical thickness of insulation for spherical surface	5	CO5	Apply K3

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I SESSIONAL TEST QUESTION PAPER 2018 – 19 EVEN SEMESTER

SCHEME AND SOLUTION

Degree : B.E
Branch : Mechanical
Course Title : Heat Transfer

Semester : VI
Course Code : 15ME63
Max Marks : 30

Q.NO.	POINTS	MARKS
1) a)	short notes on semi infinite solids	3 + 2 = 5
b)	Tcenter=61^{0}C , $T_{(r,t)}$ =59.56^{0}C ,Q=28.36kJ	2 + 3 = 5
c)	Z=0.5, x=0.0167m	3 + 2 = 5
2) a)	Short notes on heisler's chart	2 + 3 = 5
b)	Tcenter=141^{0}C , $T_{(x,t)}$ =137.7^{0}C , Q=14.4MW	2 + 3 = 5
c)	F_0=0.58, t =1318Sec	2 + 3 = 5

3) a)	significance of dimesionless no i) Grashoff number ii) Prandtl number iii) Nusselt number iv) Reynolds number	2 3 } 5
b)	a) δh_x=6.29*10^{-3}m, b) δt_x =7.12*10^{-3} c) C_{fx}=2.88*10^{-3}, d) h_x=6.45w/m^2K e) h=12.9 w/m^2K f) Q=40.45 W	2 3 } 5
c)	**Qbare=0.377W , Qsheathed =0.804W**	2 3 } 5
4 a)	Using Buckingham theorem, prove that Nu=(Re * Pr)	3 2 } 5
b)	h=114.92 w/m^2K, Q=1880.1W, ,L=5.37m	2 3 } 5
c)	r_c=2k/h_0 , **Critical thickness of insulation =(2k/h_0)-r_i**	2 3 } 5

Signature of Course in charge

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III SESSIONAL TEST QUESTION PAPER 2018 – 19 EVEN SEMESTER

SET – A

USN										

Degree	:	B.E	Semester	:	VI A & B
Branch	:	Mechanical Engineering	Course Code	:	15ME63
Course Title	:	Heat Transfer	Date	:	21-05-2019
Duration	:	90 Minutes	Max Marks	:	30

Note: Answer ONE full question from each part.

Q No.	Question	Marks	CO mapping	K-Level
	PART-A			
1(a)	Consider the body of a man as vertical cylinder of 300 mm diameter and 160 cm height. If the temperature of body is to be maintained at 36^0C. **Calculate** heat generated in 24 hours , ambient temperature is 14^0C	5	CO3	K3 APPLYING
(b)	Two vertical plates each 80mm high and 85^0C are placed in a tank of water at 15^0C. **Calculate** the minimum spacing which will prevent interface of free convection boundary layer.	5	CO3	K3 APPLYING
(c)	With neat diagram **explain** the regimes of pool boiling.	5	CO5	K2 UNDERSTANDING
	OR			
2(a)	A square plate 0.5m x 0.5 m with one surface insulated and other surface maintained at a temperature of 42^0C **calculate** average heat transfer coefficient for free convection for the fallowing orientations of hot surfaces take ambient temperature as 23^0C i) the plate is horizontal & hot surface faces up ii) the plate is horizontal & hot surface faces down.	5	CO3	K3 APPLYING
(b)	Estimate the heat transfer rate from 100W incandescent bulbs at 140^0C to an ambient at 24^0C.Approximate the bulb as 6cm diameter sphere. **Calculate** the percentage of power lost by natural convection. Use $N_u=0.60\ (G_rP_r)^{1/4}$	5	CO3	K3 APPLYING
(c)	**Distinguish** between Film wise condensation and drop wise condensation.	5	CO5	K2 UNDERSTANDING
	PART-B			
3(a)	**Derive** an expression for LMTD of i) Parallel flow heat exchanger. State the assumptions made.	5	CO4	K3 APPLYING
(b)	Exhaust gas flowing through heat exchanger at a rate of 20kg/min are cooled from 400^0C to 120^0C by water initially at 10^0C. specific heat of gases may be taken as 1.13kJ/kg K & overall heat transfer coefficient is 139.52 w/m^2K if water flow rate is 25kg /min **calculate** surface area needed for a) parallel flow b) counter flow arrangements	5	CO4	K3 APPLYING
(c)	A vertical tube of 60 mm outside diameter and 1.2m long is exposed to steam at atmospheric pressure. The outer surface of the tube is maintained at a temperature	5	CO5	K3 APPLYING

	... by circulating cold water through the tube. **Calculate** the following: i) The rate of heat transfer to the coolant ii) The rate of condensation of steam			
	OR			
4(a)	**Derive** an expression for effectiveness of counter flow heat exchanger	5	CO4	K3 APPLYING
(b)	A cross flow heat exchanger (both fluid unmixed) and having heat transfer area of 8.4 m^2 is to heat air (Cp= 1.005kJ/kg K) with water (Cp= 4.187kJ/kg K). Air enters the exchanger at 18^0C with mass flow rate of 2kg/s while water enters at 90^0C with mass flow rate of 0.25kg/s the overall heat transfer coefficient is 250 W/m^2K. **Calculate** exit temperature of two fluids & heat transfer rate	5	CO4	K3 APPLYING
(c)	A vertical cooling fin approximates a flat plate of 40cm height exposed to a saturation steam at 100^0C (h_{fg}=2257 kJ/kg). The fins maintained at a temperature of 90^0C.Calculate i) Thickness of film at bottom of fin. ii) Average heat transfer coefficient iii) Heat transfer rate after incorporating Mc Adam's correction.	5	CO5	K3 APPLYING

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K.S.INSTITUTE OF TECHNOLOGY, BENGALURU – 560109

DEPARTMENT OF MECHANICAL ENGINEERING

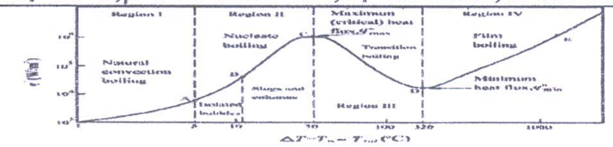
SCHEME AND SOLUTION OF INTERNAL ASSESMENT TEST – III

Course Title: Heat Transfer | **Maximum Marks: 30**

Course Code: 15ME63 | **Year / Semester: III/VI**

Date: 21/5/19 | **Time Duration: 1.30 hrs**

Part - A

Question Number		Solution	Marks Allotted
1	a	Gr=1.23x10^{10}, h=3.35w/m2K, Q=9602kJ/hr	5
	b	T_f=50^{0}C,β=3.096X$10^{-3}$$K^{-1}$,$G_r$=3.54x$10^9$, δ=9.97X$10^{-4}$, b=1.995mm	5
	c		5
OR			
2	a	Lc= 0.125m, Gr=4.65x10^6 i) h= 4.911w/m^2K ii) h=2.45W/m^2k	5
	b	T_f=82^{0}C,β=2.88X$10^{-3}$$K^{-1}$,$G_r$=1.503x$10^6$, N_u=19.21, h=9.73w/m^2K,Q=12.76W,%of power lost by natural convection=12.76%	5
	c	Difference between film wise condensation and drop wise condensation (Minimum five difference)	5
3	a	Assumptions $Q=m_hC_{ph}(T_{hi}-T_{ho})= m_cC_{pc}(T_{co}-T_{ci})$ $\Theta=T_h-T_c$ LMTD=$\theta_1- \theta_2/\ln(\theta_1/ \theta_2)$	5
	b	a)As= 4.535m^2 for parallel b) As=3.73m^2 for counter flow	5
	c	h=3457.62w/m^2K, Q= 39104.85W , ms=62.37kg/hr	5
OR			
4	a	$\varepsilon=Q_{act}/Q_{max}$, $C=C_{min}/C_{max}$, $NTU=UA/C_{min}$, $\varepsilon=1-e^{-NTU(1-C)}/(1-C\, e^{-NTU(1-C)})$	5
	b	Ch=1045, Cc= 2010, NTU =2.10, Tho= 38.16^{0}C, Q=54.173kW	5
	c	T_f=95^{0}C,δ=1.124X10^{-4}mm,h=8073.17w/m^2 K, h=9687.80 w/m^2 K, Q=38571.21W	5

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III SESSIONAL TEST QUESTION PAPER 2018 – 19 EVEN SEMESTER

SET – B

USN | | | | | | | | | | |

Degree	: **B.E**	**Semester :**	**VI A & B**
Branch	: **Mechanical Engineering**	**Course Code :**	**15ME63**
Course Title	: **Heat Transfer**	**Date :**	**21-05-2019**
Duration	: **90 Minutes**	**Max Marks :**	**30**

Note: Answer ONE full question from each part.

Q No.	Question	Marks	CO mapping	K-Level
	PART-A			
1(a)	A square plate 0.5m x 0.5 m with one surface insulated and other surface maintained at a temperature of 42^0C **calculate** average heat transfer coefficient for free convection for the fallowing orientations of hot surfaces take ambient temperature as 23^0C i) the plate is horizontal & hot surface faces up ii) the plate is horizontal & hot surface faces down.	5	CO3	K3 APPLYING
(b)	Estimate the heat transfer rate from 100W incandescent bulbs at 140^0C to an ambient at 24^0C.Approximate the bulb as 6cm diameter sphere. **Calculate** the percentage of power lost by natural convection. Use $N_u=0.60\,(G_rP_r)^{1/4}$	5	CO3	K3 APPLYING
(c)	**Distinguish** between Film wise condensation and drop wise condensation.	5	CO5	K2 UNDERSTANDING
	OR			
2(a)	Consider the body of a man as vertical cylinder of 300 mm diameter and 160 cm height. If the temperature of body is to be maintained at 36^0C. **Calculate** heat generated in 24 hours , ambient temperature is 14^0C.	5	CO3	K3 APPLYING
(b)	Two vertical plates each 80mm high and 85^0C are placed in a tank of water at 15^0C. **Calculate** the minimum spacing which will prevent interface of free convection boundary layer.	5	CO3	K3 APPLYING
(c)	With neat diagram **explain** the regimes of pool boiling.	5	CO5	K2 UNDERSTANDING
	PART-B			
3(a)	**Derive** an expression for LMTD of i) Counter flow heat exchanger. State the assumptions made.	5	CO4	K3 APPLYING
(b)	A cross flow heat exchanger (both fluid unmixed) and having heat transfer area of 8.4 m^2 is to heat air (Cp= 1.005kJ/kg K) with water (Cp= 4.187kJ/kg K). Air enters the exchanger at 18^0C with mass flow rate of 2kg/s while water enters at 90^0C with mass flow rate of 0.25kg/s the overall heat transfer coefficient is 250 W/m^2K. **Calculate** exit temperature of two fluids & heat transfer rate.	5	CO4	K3 APPLYING

	[illegible]al cooling fin approximates a flat plate of 40cm [illegible]ght exposed to a saturation steam at 100^0C (h_{fg}=2257 kJ/kg). The fins maintained at a temperature of 90^0C.Calculate i) Thickness of film at bottom of fin. ii) Average heat transfer coefficient iii) Heat transfer rate after incorporating Mc Adam's correction.	5	CO5	K3 APPLYING
OR				
4(a)	**Derive** an expression for effectiveness of Parallel flow heat exchanger	5	CO4	K3 APPLYING
(b)	Exhaust gas flowing through heat exchanger at a rate of 20kg/min are cooled from 400^0C to 120^0C by water initially at 10^0C. specific heat of gases may be taken as 1.13kJ/kg K & overall heat transfer coefficient is 139.52 w/m^2K if water flow rate is 25kg /min **calculate** surface area needed for a) parallel flow b) counter flow arrangements.	5	CO4	K3 APPLYING
(c)	A vertical tube of 60 mm outside diameter and 1.2m long is exposed to steam at atmospheric pressure. The outer surface of the tube is maintained at a temperature of 50^0C by circulating cold water through the tube. **Calculate** the following: i) The rate of heat transfer to the coolant ii) The rate of condensation of steam.	5	CO5	K3 APPLYING

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Set B

K.S.INSTITUTE OF TECHNOLOGY, BENGALURU – 560109
DEPARTMENT OF MECHANICAL ENGINEERING

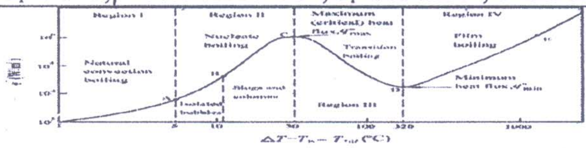
SCHEME AND SOLUTION OF INTERNAL ASSESMENT TEST – III

Course Title: Heat Transfer **Maximum Marks: 30**

Course Code: 15ME63 **Year / Semester: III/VI**

Date: 21/5/19 **Time Duration: 1.30 hrs**

Part - A

Question Number		Solution	Marks Allotted
1	a	Lc= 0.125m, Gr=4.65x10^6 i) h= 4.911w/m^2K ii) h=2.45W/m^2k	5
	b	T_f=82^{0}C,β=2.88X$10^{-3}$$K^{-1}$,$G_r$=1.503x$10^6$, N_u=19.21, h=9.73w/m^2K,Q=12.76W,%of power lost by natural convection=12.76%	5
	c	Difference between film wise condensation and drop wise condensation (Minimum five difference)	5
OR			
2	a	Gr=1.23x10^{10}, h=3.35w/m2K, Q=9602kJ/hr	5
	b	T_f=50^{0}C,β=3.096X$10^{-3}$$K^{-1}$,$G_r$=3.54x$10^9$, δ=9.97X$10^{-4}$, b=1.995mm	5
	c		5
3	a	Assumptions $Q=m_hC_{ph}(T_{hi}-T_{ho})= m_cC_{pc}(T_{co}-T_{ci})$ $\Theta=T_h-T_c$ LMTD=θ_1- θ_2/ln(θ_1/ θ_2)	5
	b	Ch=1045, Cc= 2010, NTU =2.10, Tho= 38.16^{0}C, Q=54.173kW	5
	c	T_f=95^{0}C,δ=1.124X10^{-4}mm,h$^-$=8073.17w/m^2 K, h=9687.80 w/m^2 K, Q=38571.21W	5
OR			
4	a	$\varepsilon=Q_{act}/Q_{max}$, $C=C_{min}/C_{max}$, $NTU=UA/C_{min}$, $\varepsilon=1-e^{-NTU(1-C)}/(1-C e^{-NTU(1-C)}$	5
	b	a)As= 4.535m^2 for parallel b) As=3.73m^2 for counter flow	5
	c	h=3457.62w/m^2K, Q= 39104.85W , ms=62.37kg/hr	5

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Branch : ME Scheme : 2015 Semester : 6

SI NO.	USN	15ME63
1	1KS14ME030	15
2	1KS14ME046	14
3	1KS14ME115	19
4	1KS15ME015	12
5	1KS15ME018	15
6	1KS15ME028	13
7	1KS15ME035	12
8	1KS15ME042	13
9	1KS15ME044	12
10	1KS15ME046	12
11	1KS15ME048	12
12	1KS15ME053	15
13	1KS15ME058	17
14	1KS15ME098	15
15	1KS15ME102	14
16	1KS15ME107	0
17	1KS15ME110	12
18	1KS16ME002	17
19	1KS16ME004	17
20	1KS16ME006	20
21	1KS16ME007	12
22	1KS16ME008	20
23	1KS16ME009	16
24	1KS16ME010	17
25	1KS16ME011	18
26	1KS16ME012	13
27	1KS16ME013	17
28	1KS16ME014	20
29	1KS16ME015	15
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38	1KS16ME027	16
39	1KS16ME028	16
40	1KS16ME029	16
41	1KS16ME030	14
42	1KS16ME031	15
43	1KS16ME032	12
44	1KS16ME033	17

45	1KS16ME035	16
46	1KS16ME036	16
47	1KS16ME038	17
48	1KS16ME040	18
49	1KS16ME044	15
50	1KS16ME045	17
51	1KS16ME046	15
52	1KS16ME047	13
53	1KS16ME048	16
54	1KS16ME049	18
55	1KS16ME052	16
56	1KS16ME053	16
57	1KS16ME054	20
58	1KS16ME055	18
59	1KS16ME056	12
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61	1KS16ME058	20
62	1KS16ME060	14
63	1KS16ME061	15
64	1KS16ME062	17
65	1KS16ME063	18
66	1KS16ME064	16
67	1KS16ME067	14
68	1KS16ME069	12
69	1KS16ME070	13
70	1KS16ME073	14
71	1KS16ME075	20
72	1KS16ME076	13
73	1KS16ME081	12
74	1KS16ME082	19
75	1KS16ME083	15
76	1KS16ME084	16
77	1KS16ME085	16
78	1KS16ME086	14
79	1KS16ME087	16
80	1KS16ME089	15
81	1KS16ME090	16
82	1KS16ME093	18
83	1KS16ME094	17
84	1KS16ME095	17
85	1KS16ME096	14
86	1KS16ME097	12
87	1KS16ME098	12
88	1KS16ME099	14
89	1KS16ME100	13
90	1KS16ME101	15
91	1KS16ME102	13
92	1KS16ME104	12
93	1KS16ME105	17
94	1KS16ME401	12

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Assistant Professor, MED

QUESTION BANK

HEAT TRANSFER (15ME63)

UNIT – 1

Introductory Concepts And Definitions: Modes of heat transfer: Basic laws governing conduction, convection, and radiation heat transfer; Thermal conductivity; convective heat transfer coefficient; radiation heat transfer;combined heat transfer mechanism. Boundary conditions of 1st, 2nd and 3rd kind.

Conduction: Derivation of general three dimensional conduction equation in Cartesian coordinate, special cases, discussion on 3-D conduction in cylindrical and spherical coordinate systems (No derivation). One dimensional conduction equations in rectangular, cylindrical and spherical coordinates for plane and composite walls. Overall heat transfer coefficient. Thermal contact resistance. **07 Hours**

1. Write down 3 – dimensional condition equation in Cartesian coordinates. Explain the meaning of each term. ***jun/jul 2013 (06M)***

2. What do you mean by initial conditions and boundary conditions of I, II, III kind? ***jun/jul 2013 (08M)***

3. A composite wall consists 10cm layer of building brick ($0.7 W/m^0C$) and 3cm plaster ($0.5W/m^0C$) . An insulating material of K= $0.08W/m^0C$ is to be added to reduce the heat transfer trough the wall by 70%. Determine the thickness of the insulating layer. j***un/jul 2013 (08M)***

4. What are the different types of boundary conditions? Explain them with available sketches for one dimensional heat condition.

jun/jul 2013 (06M)

5. Consider a solid cylinder of radios r= b in which energy is generated at a constant rate of go W/M^3, while the boundary surface at r=b is maintained at a constant temperature T2 develop an expression for the one- dimensional, radial, steady state temperature distribution T(r) and heat flux q(r) ***jun/jul 2013 (06M)***

6. A steel tube is covered with a layer of insulation made of asbestos material. This tube is used for the flow of hot gases. The following data is given ID of steel tube = 75 mm, OD of steel tube = 100 mm. Thickness of asbestos layer = 30 mm, Temperature of hot gases = 350^0 C, Temperature of outside ambient air 40^0 C, K for steel – 50 w/M-k, K of asbestos layer – 0.15 w/M-k, convective heat transfer coefficients fort hot gases and ambient air are 300 and 20 w/m^2-k respectively. ***jun/jul 2013 (08M)***

8. An electrical resistance of mattress type is inserted in between two slabs of different materials on a panel heater. On one side, the material has a thermal conductivity of 0.174W/m ^{2}K and 10mm thick. On the other side of the heater the material has a thermal conductivity of 0.05W/m °K and 25mm thick. The

convection heat transfer co-efficient from the thinner and thicker slabs are 23.26 and 11.63 W/m^2°K. The temperature of the surrounding air on both the sides is 15°C. If the energy dissipation for each square meter of the mattress is 5kW, neglecting edge effects, find (i) The surface temperature of the slab,
(ii) The temperature of the mattress assuming it to be the same as the inner surface of the Slabs ***June-july 2009***

9. Explain briefly: i) Thermal conductivity ii) Thermal diffusivity iii) Thermal contact resistance. ***(06 Marks) December 2010***

10. The walls of a house in cold region consist of three layers, an outer brick work 15 cm thick. an inner wooden panel 1.2 cm thick, the intermediate layer is made of an insulating material 3 7 cm thick. The thermal conductivity of brick and wood are 0.7 W/mk and 0.18 W/mk| respectively. The inside and outside temperatures of the composite wall are 21 °C and -15°C respectively. If the layer of insulation offers twice the thermal resistance of the brick wall, calculate,

i) Heat loss per unit area of the wall.

ii) Thermal conductivity of insulating material. • ***(06 Marks) December 2010***

11. An insulated steam pipe having outside diameter of 30 mm is to be covered with two layers of insulation, each having a thickness of 20 mm. The thermal conductivity of one material is 3 times that of the other. Assuming that the inner and outer surface temperatures of composite insulation are fixed, how much heat transfer will be increased when the better insulation material is next to the pipe than when it is at the outer layer? ***08 Marks) December 2010***

12. State the laws governing three basic modes of heat transfer.
(06 Marks) May/June 2010

13. Derive the general three-dimensional conduction equation in Cartesian coordinates and state the assumptions made.
(08 Marks) May/June 2010

14. A composite wall is made up of three layers of thicknesses 25 cm, 10 cm and 15 cm of material A, B and C respectively. The thermal conductivities of A and B are 1.7 W/mK and 9.5 W/mK respectively. The outside surface is exposed to air at 20°C with convection coefficient of 15 W/m^2K and the inside is exposed to gases at 1200°C with a convection coefficient of 28 W/m^2K and the inside surface is at 1080°C. Determine the unknown thermal conductivity of layer made up of material C . ***(06 Marks) May/June 2010***

15 Starting from fundamental principles, derive the general, three-dimensional heat conduction equation in Cartesian co-ordinates. ***(9 mks) December 2012***

QUESTION BANK

16 A liquid at 1000 C flows through a pipe of 40mm outer and 30mm inner diameter. Thermal conductivity of pipe material is 0.5 W/m^2K. The pipe is exposed to air at 40^0C. the inner end and outer convective heat transfer co-efficient are 300 W/m K and 5 W/m k respectively. Calculate the overall heat transfer co-efficient and the heat loss per unit length of pipe. **(8 mks)** ***Dec 2012***

17 What is the technical need to undertake a detailed study of heat transfer, having studied thermodynamics already? ***(3 mks) December 2012***

18. What do you mean by boundary condition of 1^{st} , 2^{nd} and 3^{rd} kind?***(06M) june 2012***

19. Derive general heat condition equation in Cartesian co-ordinates.
(08 M) june 2012, (08 M) jan 2017

20. A 0.8 m high and 1.5 m wide double plane window consists of two 4 mm thick layers of glass ($k=78W/m^2C$),separated by a 10 mm wide stagnant air space ($k=0.026\ W/m^2C$) determine the rate of heat transfer through this window and the temperature of the inside surface, when the room is maintained at 20^0C and the outside air is at -10^0C take the convention heat transfer co efficient on the inside and outside surfaces of the window as 10 and 40 W/mC respectively. ***(06 marks) june 2012***

21 .Explain brifly i) thermal conductivity ii) thermal diffisuvity iii) Overall heat transfer coefficient . ***10M(Dec 2011)***
22. Derive the general three dimensional conduction equation in Cartesian co ordinates and state the assumptions made. ***10M (Dec 2011)***

23 .A square plate heater of size 20cmsx20cms is inserted between two slabs. Slab' A' is 3cms thick (K=50 W/mK) and slab 'B' is 1.5 cms (K=50 W/mK). The outside heat transfer coefficients on both sides of A and B are 200 and 50 W /m^2 K respectively temperature of surrounding air is 250C . if the rating of the heater is 1kW, find i)Maximum temperature in the system. ii) Outer surface temperature of two slabs. Draw the equivalent circuit for the system. ***10M.(Dec 2011)***
24.Derive general 3- Dimensional conduction equation in Cartesian coordinates**.**
10M (june/july 2011)

25. Write the mathematical formulation of one dimensional, steady state heat conduction for a hollow sphere to sphere with constant thermal conductivity in region a≤r≤b , when heat is supplied to sphere at a rate of q0W/ m2 for boundary surface at r=b in to medium at zero temperature with a heat transfer coefficient 'h'. ***10M (june/july 2011)***

QUESTION BANK

26. A steam pipe with internal and external diameter 18 cm and 12 cm is covered with two layers of insulation each 30mm thick with thermal conductivities 0.18 W/mK and 0.09 W/mK. The difference in temperature between in side and outside surfaces is 2500C calculate the quantity of heat lost per meter length of the pipe if its thermal conductivity is 60 W/mK. What is the percentage error if the calculation is carried out considering the pipe. ***10M (june/july 2011)***

27. Write down 3 - dimensional conduction equation in Cartesian coordinates, explain the meaning of each term. ***(06 Marks)july 2013***

28. What do you mean by initial conditions and boundary conditions of I, II & III kind? ***(06 Marks)july 2013***

~~**29.** A composite wall consists of 10cm layer of building brick (0.7W/m°C) and~~ 3cm plaster (0.5W/m°C). An insulating material of K = 0,08 W/m°C is to be added to reduce the heat transfer through the wall by 70%. Determine the thickness of insulating layer**,** ***(08 Marks)july 2013***

30. Explain briefly the mechanism of conduction, convection and radiation heat transfer **(06 Marks)jan 2014, (03 Marks)jan 2017**

31. With sketches, write down the mathematical representation of three commonly used different types of boundary conditions for one dimensional heat equation in rectangular coordinate. (08 marks) **jan 2014**

32. A plate of thickness 'L' whose one side is insulated and the., other side is maintained at **a**tmosphere T_1 exchanging heat by convection to the surrounding area at a temperature T_2 with atmospheric air being the outside medium. Write mathematical formulation for one dimensional, steady state heat transfer, without heat generation. **(06 Marks} jan 2014**

33. State the laws governing three modes of heat transfer. **(06 Marks)June 2015**

34. A furnace has a composite wall constructed of a refractory material for the inside layer and an insulating material on the outside. The total wall thickness is limited to 60 cms. The mean temperature of the gases within the furnace is 850^o C, the external air temperature is 30^oC and the temperature of the interface of the two materials of the furnace wall is 500^oC. The thermal conductivities of refractory and insulating materials are 2 and 0.2 W/m-K respectively. The coefficients of heat transfer between the gases and refractory surface is $200 W/m^2$-K and between outside surface and atmosphere is 40 W/m^2-K. Find:

i) The required thickness of each material

ii) The rate of heat loss. **(04 Marks)June 2015**

35. A small electric heating application uses 1.82 mm diameter wire with 0.71 mm thick insulation. K (insulation) = 0.118 W/ m-K, and h_o = 34.1 W/m^2-K. Determine the critical thickness of insulation for this case and change in heat transfer rate if critical thickness was used. Assume the temperature difference between surface of wire and surrounding air remain unchanged.**(06 M) june 2015**

36. The wall of a house in a cold region consists of three layers, an outer brick work 20cm thick, an inner wooden panel 1.4cm thick and an intermediate layer made of an insulating material 10 cm thick. the inside and outside temperature of the composite wall are 28^0c and -12^0c respectively. The thermal conductivity of brick and wood are 0.7 W/mk. And 0.18 W/mk respectively. If the layer of insulation has a thermal conductivity of 0.023 W/mk,find i)the heat loss per unit area of the wall ii)overall heat transfer coefficient. (**09 M) june 2017**

UNIT – 2

Variable Thermal Conductivity: Derivation for heat flow and temperature distribution in plane wall. Critical thickness of insulation without heat generation, Thermal resistance concept & its importance. Heat transfer in extended surfaces of uniform cross-section without heat generation, Long fin, short fin with insulated tip and without insulated tip and fin connected between two heat sources. Fin efficiency and effectiveness. Numerical problems.
06 Hours

1. Obtain an expression for heat transfer through a plane wall in which thermal conductivity is given by $K = K_0(1+ \alpha\ t)$, where α is constant , K_0 thermal conductivity at reference temperature T is the Temperature. ***jun 2013(02M)***

2. Derive an expression for critical thickness of insulation for a cylinder.
jun/jul 2013 (06M)

3. A wire of 8mm diameter at a temperature of 60^0Cis to be insulated by a material having K = 0.174W/m 0C. Heat transfer coefficient ha = $8W/m^2K$ and ambient temperature Ta= 25^0C . for max heat loss find the maximum thickness of insulation. Find increase in heat dissipation due to insulation. ***jun2013 (08M)***

4 . What is the critical thickness of insulation? Derive an expression for the critical thickness of insulation for a spare. ***jun/jul 2013 (05M)***

5. Obtain an expression for the temperature distribution and heat flow through a rectangular fin, when the end of the fin is insulated. ***jun/jul 2013(10M) jan2017***

6. The temperature of the air steam in a tube is measured with the help of a thermometer placed into a protective well filled with oil, The thermometer well is made of a steel tube(k- 55.8 W/m-K), 120 mm long and 1.5 mm thick. The heat transfer coefficient between the following air and protective well is 23.3 W/m^2-K and temperature recorded by the thermometer is 84^0C. Estimate the error in the measurement if the temperature at the base of the well is 40^0C.
. ***jun/jul 2013 (05M)***

7. Derive an expression for the temperature distribution for a pin fin, when the tip of the fin is insulated. (08 Marks) . ***June-july 2009***

8 A steel pipe of 220mm OD is carrying steam at 280°C. It is insulated with a material with K=0.06[l + 0.0018T1 where ' K ' is in W/m °K. Thickness of insulation is 50mm and the outer surface temperature is 50°C. Determine the heat flow per 'm' length of the pipe and the temperature at the mid thickness of the pipe. (12 Marks) ***June-july 2009***

9 It is desired to increase the heat dissipation over the surface of an electronic device of spherical shape of 5mm radius exposed to convection with h = 10 W/m^2K by encasing it in a transparent spherical sheath of K = 0.04 W/mK. Determine the diameter of the sheath for maximum heat flow. For a temperature drop of 120°C from the device surface, determine the heat flow for bare and sheathed device. (10 Marks) ***May/June 2010***

10)A rod (K = 200 W/mK) 5mm in diameter and 5cm long has its one end maintained at 100°C. The surface of the rod is exposed to ambient air at 25°C with convection heat transfer coefficient of 100 W/m2K. Assuming other end insulated, determine

i) The temperature of the rod at 20mm distance from the end at 100°C.
ii) Heat dissipation rate from the surface of the rod and
iii) Effectiveness. (10 Marks) ***May/June 2010***

11 Define fin efficiency and fin effectiveness with respect to a fin with insulated tip. **(04 Marks)** ***December 2010***

12. What is the physical significance of critical thickness of insulation? Derive an expression for thickness of insulation for a sphere. ***(06 Marks) December 2010***

13 The handle of a ladle used for pouring molten metal at 327°C is 30 cm long and is made of 2.5 cm x 1.5 cm mild steel bar stock (K = 43 W/mK). In order to reduce the grip temperature g | it is proposed to make a hollow handle of mild steel plate of 0.15 cm thick to the same rectangular shape. If the surface heat transfer coefficient is 14.5 W/m2K and the ambient temperature is at 27°C, estimate the reduction in the temperature of grip. Neglect the heat transfer from the inner surface of the hollow shape.
(10 Marks) December 2010

14 A tube with an outer diameter of 20mm is covered with insulation. The thermal conductivity of insulating material is 0.18 W/mK. The outer surface losses heat by convection with a heat transfer co-efficient of $12W/m^2K$. determine the crictical thickness of insulation. Also calculate the ratio of heat loss from the tube with critical thickness of insulation to that from the bare tube (without insulation). ***(10 Marks) December 2012***

15 Derive the one–dimensional fin equation for a fin of uniform cross section. By integrating the fin eqation, obtain the expression for the temperature variation in a long fin. (10 mks) ***(10 Marks) December 2010***

16 What is physical significance of critical thickness of insulation? Derive an expression for critical thickness of insulation for a cylinder . . ***(06 marks) june 2012***

17 Derive an expression for temperature distribution for a pin fin with the tip insulated. ***(08 marks) june 2012***

18 A carbon steel (k=54W/m^2c) rod with a cross section of an equilateral triangle (each side5mm) is 80mm long. It is attached to a plane wall witch is maintained at a temperature of 400^0C the surrounding environment is at a 50^0C and unit surface conductance is 90W/m^2C compute the heat dissipated by the rod (assuming tip is insulated) ***(06 marks) june 2012***

19.) Derive an expression for the temperature distribution for long pin of uniform cross section without insulated tip. . ***10M (Dec 2011)***

20. A rod (K=200W/mK) 10 mm in diameter and 5 cms long has its one end maintained at 1000c . the surface of the is exposed to ambient air at 300C with convective heat transfer coefficient of 100 W/m2K. Assuming otherend insulated, determine i) The temperature of the rod at 25mm distance from the end at 1000C ii)Heat dissipation rate from the surface of rod and iii) Effectiveness.

10M.(Dec 2011)

21. Clearly define i) Fine efficiency ii) Fin effectiveness. ***10M (june/july 2011)***

22. Derive an expression for rate heat transfer and temperature distribution for a plane wall with variable thermal conductivity. ***10M (june/july 2011***

23. Thin fins of brass whose K=75W/mK are welded longitudinally on a 5 cm diameter brass cylinder which stands vertically and is surrounded by air at 200C. The heat transfer coefficient from metal surface to air is 17 W/ m2K. If 16 uniformly spaced fins are used each 0.8mm thick extending 1.25 cm from cylinder, whatb is the rate of heat transfer from the cylinder per unit length to the air when cylinder surface is maintained at 1500C? ***10M (june/july 2011***

24. Obtain an expression (or heat transfer through a plane wall in which thermal conductivity is given by K = Ko (l+ αT) , where a is constant, Ko thermal conductivity ai reference temperature T is the temperature. ***(06 Marks)July 2013***

25. Derive an expression for critical thickness of insulation for a cylinder. ***(06 Marks)july 2013***

26.A wire of 8mm diameter at a temperature of 60°C is to be insulated by a material having K = 0.174W/m °C. Heat transfer coefficient h_a= 8W/^{2}mK and ambient temperature Ta = 25°C. For max heat loss find the minimum thickness of insulation. Find increase in heat dissipation due to insulation.

(08 marks) july 2013

27. An electric cable of 10mm diameter is to be.laid in atmosphere at 20°C. The estimated surface temperature of the cable due to heat generation is 65°C. Find the maximum percentage increase in heat dissipation, when the wire is insulated with rubber having K = 0.155 W/mK. Taken = 8.5 W / m2K ***(06 Marks) july14***

28. Differentiate between the effectiveness and efficiency of Fins.

(04 Marks) july 14

29. In order to reduce the thermal resistance at the. surface of a vertical plane wall (50 x 50cm), 100 pin fins (l ' cm diameter, 10pm long) are rattached. If the pin fins are made of copper having a thermal conductivity of 300 W/mK and the value of the surface heat transfer coefficient is 15 W/m2k**.** calculate the decrease in the thermal resistance. Also calculate the consequent increase in heat transfer rate from the wall i f it is maintained at a temperature of| 200°C and the surroundings are at 30°C. ***(10 Marks) july 14***

30. Derive an expression for the temperature distribution for a short fin of uniform cross section without insulated tip starting from fundamental energy balance equation. ***(10M)june 2015***

31. Determine the amount of heat transferred through an iron fin of thickness 5 mm, height 50mm and width 100 cms. Also determine the temperature of the centre of the fin end of the tip of fin. Assuming atmospheric temperature of 28^{o}C. Take K = 50 W/m-K, h = 10 W/m^{2}-K, base fin temperature = 108^{o}C.

(10 Marks)June 2015

32. The aluminum square fins (0.6*0.6),12mm long are provided on the surface of a semi conductor electronic device to carry 2W of energy generated. The temperature at the surface of the device should not exceed 85^{0}C,when the surrounding is at 35^{0}. Given K=200W/mK, h=15w/m^{2}k.Determine the number of fins required to carry out the above duty.Neglect the heat loss from the end of the fin. ***(10 Marks)Jan 2017***

UNIT – 3

One-Dimensional Transient Conduction: Conduction in solids with negligible internal temperature gradient (Lumped system analysis), Use of Transient temperature charts (Heisler's charts) for transient conduction in slab, long cylinder and sphere; use of transient temperature charts for transient conduction in semi-infinite solids. Numerical Problems.
06 Hours

1. Derive an expression for temperature distribution in a lumped system. Also derive equation for instantaneous rate of heat flow and to energy transfer for the given time . ***. jun/jul 2013 (12M)***

2. A person is found dead at 5PM in a room which is at 20^0 C. The temperature of the body is measured to be 25^0C when found and heat transfer coefficient is estimated to be 8 W/m2-K. Modeling the body as a short cylinder of 30 cm diameter and 1.7 m long estimate the time of death of that person. Use the lumped system of analysis and assume the following properties K=0.617W/m-K, S= 996kg/m^3, C_P=4187J/KG-k. Temperature of the body before dead=37^0C. ***jun/jul 2013 (05M)***

3. One surface of a thick Nickel steel (K= 19 W/m-K, $\alpha = 0.52*10^{-5} m^2/s$) slab, which is initially at 30^0C, is suddenly raised to a temperature of 530^0C. By treating this as a one dimensional transient conduction problem in a semi infinite

medium, determine the temperature at a depth of 50 mm after a time of 50 seconds. ***jun/jul 2013 (03M***

4. Obtain an expression for instantaneous heat transfer and total heat transfer for lumped heat analysis treatment heat conduction problems. ***jun/jul 2013 (08M***

5. Explain physical significance of Biot and Fouriar numbers. ***jun/jul 2013 (06M)***

6. A household electric iron (ρ= 2700kg/m3,Cp = 0.896 kj/kg K and K= 200W/m0C) and weighs 1.5 kg. The total area of iron is 0.06m2 and it is heated with 500W heating element. Initially the iron is at 250C, How long it take for the iron to reach 1100C. Take ha = 15W/m2K. ***jun/jul 2013 (06M)***

7. Derive an expression for the instantaneous and total heat flow in terms of the product of Biot Number and Fourier Number in one dimensional transient heat conduction. (08 Marks) ***June-july 2009***

8. A 5cm thick iron plate with K = 60 W/m °K, Cp = 460 J/kg °C, ρ = 7850 kg/m3, α=1.6xl0'5 m2/s is initially at 225°C. Suddenly both the surfaces are exposed to an environmental temperature of 25°C with a convective heat transfer co-efficient of 500W/m2 °K. Calculate i) the centre temperature at t = 2 min after start of cooling, ii) the temperature at a depth of 1 cm from the surface at t = 2 min after the start of cooling, iii) the energy removed from the plate per m2 during this time. (12 Marks***) June-july 2009***

9)A thermocouple junction, which may be approximated as a sphere, is to be used for temperature measurement in a gas stream. The convection coefficient between the junction surface and the gas is 400 W/m2K and the junction thermo physical properties are K = 20 W/mK, Cp = 400 J/kgK, ρ - 8500 kg/m3. Determine the junction diameter needed forthe thermocouple to have a time constant of 1 s. If the junction is at 25°C and is placed in agas stream that is at 200°C, how long will it take for the junction to reach 199°C? (10 Marks) ***May/June 2010***

10) A large slab of wrought iron is at a uniform temperature of 375°C. The temperature of one surface of this slab is suddenly changed to 75°C. Calculate the time required for the temperature to reach 275°C at a depth of 5 cm from the surface and the quantity of energy transferred per unit area of the surface during this period. Take K = 60 W/rnK andα=1.626*10-5m2/s. ***(10M)May/June 10***

11. Obtain an expression for instantaneous heat transfer and total heat transfer for lumped heat analysis treatment of heat conduction problems. (08 Marks ***December 2010***

12. Explain the physical significance of Biot number and Fourier number. (04 Marks) ***December 2010***

13. An aluminium sphere weighing 5.5 kg and initially at a temperature of 290°C is suddenly immersed in a fluid at 15°C. The convective heat transfer coefficient is 58 W/m^2K. Estimate the time required to cool the aluminium to 95°C using the lumped capacity method of analysis (For aluminium,ρ= 2700 kg/m3. C - 900 J/kgK, K = 205 W/mK) (08 Marks) ***December 2010***

14 What are biot and fouries number? Explain their physical significance.
. ***(06 M)June 2012***

15 Obtain an expression for instantaneous heat transfer and total heat transfer for lumped heat analysis treatment heat conduction problems ***(08M) December 2010***

16 A solid copper sphere of 10cm dia [density 8954 kg/m^3, specific heat $383j/kg^0C$, thermal conductivity $366W/m^{20}C$] initially at a uniform temp $t1=250^0C$ is suddenly impressed in a well stirred fluid which is maintained at a uniform temperature $ts=50^0C$, the heat transfer co-efficient between the soher and the fluid is $200W/m^2\ ^0C$, determine the temperature of the copper block at 5 minutes after the immersion.

17 Consider a solid, with an uniform initial temperature, suddenly immersed in a liquid. Derive the relavent governing differential equation, considering the system as lumped. By solving the differential equation, obtain the expression for the temperature variation with time. ***(10 mks) December 2010***

18 A 50mm thick iron plate(K=60 W/mK, C_p=460 J/kgK, ρ=7800 kg/m^3 , α=1.6×10^{-5}m^2/s) is initially at 225^{0}C. Suddenly both surfaces are exposed to a fluid at 25^{0}C, with a heat transfer co-efficient of 500 W/m^{2}K. Calculate the centre and the surface temperatures 2 minutes after the cooling begins using Heisler's charts. ***(10M) December 2010***

19. Explain the physical significance of Biot number and Fourier number.

10M.(Dec 2011)

20. Obtain an expression for instantenious heat transfer and total heat transfer for lumped heat analysis treatment of heat conduction problem. ***10M.(Dec 2011)***

21.A 15mm diameter mild steel sphere K=42W/m0C is exposed tocooling air flow at 200Cresulting in the convective co efficient h=120 W/m20C.Determine the following:i) Time required to cool the sphere from 5500C to 900C ii)Instanteneous heat transfer rate 2 minutes after the start of cooling. For mild steel ρ̇ =7850 kg/m3, Cp=475j/ Kg0C, α=0.045m2/hr. . ***10M (Dec 2011)***

22. Define i) Biot number ii) Fourier number ***10M (june/july 2011***

23. Show that the temperature distribution under lumped analysis is given by $\frac{T-T_\infty}{T_0-T_\infty} = e - BiFo$ where T0 is the initial temperature and T∞ is the surrounding temperature. ***10M (june/july 2011***)

24. A long cylinder 12 cm in diameter and initially at 200C is placed in to furnace at 8200 C with local heat transfer coefficient of 140 W/ m2K. Calculate the time required for the axis temperature to reach 8000C. Also calculate the corresponding temperature at radius of 5.4 cm at the time Take α=6.11x10-6 m2/s,K=21W/mK. ***10M (june/july 2011)***

25. Obtain an expression for instantaneous heat transfer and total heat transfer for lumped heat analysis treatment heal conduction problems. ***(08 Marks) july 14***

26.Explain physical significance of Biot and Fourier numbers. ***(06 Marks) july 14***

27 A household electric Iron (p - 2700 kg/m\„ = 0.896 kJ/kg K and K 200W/m°C) and weighs' 1.5 kg. The total area of iron is 0.06m2 and it is heated with 500W heating element. Initially the iron is at 25°C (ambient Tempi). How long it takes for the iron to reach 110°C.Take ha= 15W/m2K. ***(06 Marks) july 14***

28. Explain physical significance of: (i) Biot number (ii) Fourier numbers.
. **(04M)june2015**

29.A steel ball of 5 cm diameter at 450oC is suddenly placed in a controlled environment of 100oC. Considering the following data, find the time required for the ball to attain a temperature of 150oC. Cp = 450 J/kg-K, k = 35 W/ m-K, h = 10 W/m2K, ρ = 8000 kg/ m3. **(06 M)june2015**

30.A long 15 cm diameter cylindrical shaft made of SS 314 (k =14.9 W/ m-K, ρ = 7900 kg/ m3) allowed to cool slowly in a chamber of 150oC with an average heat transfer coefficient of 85 W/m2K. Determine: (i) Temperature of the centre of the

shaft 25 minutes after the start of cooling process.(ii) Surface temperature at that time(iii) Heat transfer/ unit length of shaft during this time period. .
(10M) june2015

UNIT – 4

Concepts And Basic Relations In Boundary Layers: Flow over a body velocity boundary layer; critical Reynolds number; general expressions for drag coefficient and drag force; thermal boundary layer; general expression for local heat transfer coefficient; Average heat transfer coefficient; Nusselt number. Flow inside a duct- velocity boundary layer, hydrodynamic entrance length and hydro dynamically developed flow; flow through tubes (internal flow discussion only). Numericals based on empirical relation given in data handbook.

Free Or Natural Convection: Application of dimensional analysis for free convection- physical significance of Grashoff number; use of correlations of free convection in vertical, horizontal and inclined flat plates, vertical andhorizontal cylinders and spheres, Numerical problems. **07 Hours**

1.With sketches, explain the velocity boundary layer and thermal boundary layer thickness for a flow over the flat plate. ***jun/jul 2013 (04M)***

2)An approximate expression for the velocity profile for laminar boundary layer flow along a flat plate is given by, $u/u_{\infty}=\sin[\frac{\pi}{2}\frac{y}{\delta}]$: where the boundary layer thickness δ is given by, $\frac{\delta}{x}=4.80\,R_{ex}^{-1/2}$. i)Develop an expression for the local drag coefficient. ii) Develop an expression for the average drag coefficient over a distance L from the leading edge of plate. ***jun/jul 2013 (08M***

3. Calculate the rate of heat loss from the top and bottom of a flat 1 m square horizontal restaurant grill heated to 227^0C and kept in an stagnant ambient air at 27^0C. ***jun/jul 2013 (08M)***

4. Define Hydrodynamic and thermal boundary layer in case of flow over a flat plate. ***jun/jul 2013 (06M)***

5. An appropriate expression for temperature profile in thermal boundary layer is given by: ***jun/jul 2013 (06M***

6. A vertical pipe 15cm OD, 1m long has a surface temperature of 90^0C, If the surrounding air is at 30^0C. What is the rate of heat loss by free convection? ***jun/jul 2013 (06M)***

7. The exact expression for local Nusselt Number for the laminar flow along a surface is given $N_u=\frac{h_0 x}{K}=0.332 Pr^{\frac{1}{3}} Re_x^{\frac{1}{2}}$ Show that the average heat transfer coefficient from x = 0 to x = L over the length ' L ' of the surface is given by $2h_l$ where h_L is the local value at**X**=L ***(08 Marks) June-july 2009***

8. A tube of 0.036m OD and 40cm length is maintained at a uniform temperature of 100°C. It is exposed to air at a uniform temperature of 20°C. Determine the rate of heat transfer from the surface of the tube when (i) the tube is vertical (ii) the tube is horizontal. ***(12 Marks) June-july 2009***

9.With reference to fluid flow over a flat plate, discuss the concept of velocity boundary layer and thermal boundary layer, with necessary sketches**.**

(5 Marks) May/June 2010

10. Air at 20°C flows over both sides of a surface of a flat plate measuring 0.2mx0.2m. The drag force was 0.075 N. Determine the velocity gradient at the surface if kinematic viscosity has a value of 15.06x10"* m2/s and density = 1.205 kg/m3. Also determine the drag coefficient, if the free stream velocity is 40 m/s.

(07 Marks) May/June 2010

11.A horizontal plate 1 mx0.8 m is kept in a water tank, with the top surface at 60°C providing heat to warm stagnant water at 20°C. Determine the value of convection coefficient. Repeat the problem for heating on bottom surface**.**

(08 Marks) May/June 2010

12. what do you mean by hydrodynamic and thermal boundary layer? How does the ratio $\frac{\delta_h}{\delta_l}$ vary with prandtl number? ***(06 Marks) December 2010***

13. Using Buckingham's it-theorem, obtain the relationship between various non-dimensionals numbers for free convection heat transfer**.**

(08 Marks) December 2010

14. Air at 20°C flows over a thin plate with a velocity of 3 m/sec. The plate is 2 m long and 1 m wide. Estimate the boundary layer thickness at the trailing edge of the plate and the total drag force experienced by the plate**.** ***(06 Marks) December 2010***

15. With reference to fluid flow over a flat plate, discuss the concepts of velocity boundary layer and thermal boundary layer, with necessary sketches.

. ***(06 M)June 2012***

16. Air at 27^{0}C and atmosphere pressur flows over a flat plat at a speed of 2m/sec, if the plate is maintained at 93^{0}C calculate the heat transfer per unit width of the plate, assuming the length of the plate along flow of air is 2 meters.

. ***(08 M)June 2012***

17. A steam pipe 5 cms dia is lagged with insulating material of 2.5 cm thick, the surface temperature is 80^{0}C and emissivity of the insulating material surface is 0.93. find the total heat loss from 10 meter length of pipe considering the heat loss by natural convection and radiation the temperature of the air surrounding the

pipe is 20^{0}C. also find the overall heat transfer co-efficient and heat transfer co-efficient of radiation ***(06 M)J(06 M)June 2012***

18. What do you mean by hydrodynamic and thermal boundary layer ? ***10M (Dec 2011)***

19. Explain physical significance of ,i) Grashoff number ii) Prandtl number iii) Nusselt number iv) Reynolds number ***10M (Dec 2011)***

20. A nuclear reactor with its core constructed of parallel vertical plates 2.2m high and 1.4 m wide has been designed on free convection of heating of liquid bismuth. The maximum temperature of plate surface limited to 9600c while the lowest allowable temperature of bismuth is 3400C. Calculate the maximum possible heat dissipation for both sides of each plate. For convective coefficient the appropriate correlation is Nu= 0.13(Gr.Pr)0.333. ***10M (Dec 2011)***

21. Using Buckingham theorem , obtain a relationship between Nu, Pr and Gr For free convection heat transfer. . ***10M (june/july 2011)***

22. Explain the development if hydrodynamic boundary layer for flow over a flat surface. ***10M (june/july 2011***)

23 .Considering the body of a man as a vertical cylinder of 300mm diameter and 170 cm height, calculate the heat generated by the body in one day . take the body temperature as 360C and atmospheric temperature as 140C ***10M (june/july 2011)***

24) Explain the significance of following non dimensional numbers (i) Prandtl number. (ii) Grahoff number. (iii) Nusselt number. **(06 Marks)june2015**

25) A steam pipe 5 cm in diameter is lagged with insulating material of 2.5 cm thick. The surface temperature is 80oC and emissivity of the insulating material surface is 0.93. Find the total heat loss from 10 m length of pipe considering the heat loss by natural convection and radiation. The temperature of the air surrounding the pipe is 20oC. Also find the overall heat transfer coefficient.

(08 Marks) june2015

26) A hot plate 1 m × 0.5 m at 130oC is kept vertically in still air at 20oC. Find: (i) Heat transfer co-efficient (ii) Heat lost to surroundings. (**06 Marks) june2015**

UNIT – 5

Forced Convections: Applications of dimensional analysis for forced convection. Physical significance of Reynolds, Prandtl, Nusselt and Stanton numbers. Use of various correlations for hydro dynamically and thermally developed flows inside a duct, use of correlations for flow over a flat plate, over a cylinder and sphere. Numericalproblems. **06 Hours**

1. Using Buckingham's π-theorem, obtain the relationship between various non-dimensional number for forced convection heat transfer. . ***jun/jul 2013 (10M)***

2. A nuclear reactor uses a heat exchanger consisting of 5 cm ID constant heat flux tube, 305 kg/s mass flow rate of a liquid metal at 200^0C is passed through the tube having wall temperature of 230^0C. Find the length of the tube required for a 10^0C rice in temperature of the fluid. Use the following properties of the fluid: $\rho = 707*10^3 kg/m^3$, $u=8*10^{-8} m^2/s$, C_p=130j/kg-K, K=12W/m-K, Average Nusselt number is given by $N_U=4.82+0.0185(R_eP_{r)})^{0.827}$. ***jun/jul 2013 (10M)***

3. Using dimensional analysis, obtain a relation between N_u, R_o, P_r for forced convection heat transfer. ***jun/jul 2013 (10M***

4. Air flows over a flat plate at 30 C, 0.04m,0.75m long, with a velocity of 20m/s. Determine the heat transfer from the surface of plate assuming plate is maintained at 90^{0}C. $N_{u=}$ 0.664 $R_e^{0.5}$ $Pr^{0.33}$ for laminar = [0.036 $R_e^{0.8}$—836]$P_r^{0.333.}$ / ***jun/jul 2013 (10M)***

5.Explain the physical significance of i) Prandtl Number ii) Reynold's Number iii) Nusselt Number iv) Grashoff Number. (08 Marks ***June-july 2009***

6 The surface temperature of a thin plate located parallel to air stream is 90°C. The free stream velocity is 60m/s and the air temperature is 10°C. The plate is 60cmwide and 45cm long in the direction of air stream. Assuming that the transitional Reynold's number is 4x105 determine i) The average heat transfer co-efficient in laminar and turbulent regions ii) Rate of heat transfer for the entire plate considering both the sides of the plate. Given that the correlations for the local Nusselt Number are $0.332 Pr^{\frac{1}{3}} Re_x^{\frac{1}{2}}$ for laminar flow and 0.028 $Pr^{\frac{1}{3}} Re_x^{0.8}$ for turbulent flow. (12 Marks) ***June-july 2009***

7 Air at 20°C and 1 atm flows over a flat plate at 35 m/s. The plate is 75 cm long and is maintained at 60°C. Assuming unit depth in the z-direction, calculate the heat transfer from the plate. (08 Marks) ***May/June 2010***

8. Air at 2 atm and 200°C is heated as it flows through a tube with a diameter of 25 mm at a velocity of 10 m/s. Calculate the heat transfer per unit length of tube if a constant heat flux condition is maintained at the wall and the wall temperature is 20°C above the air temperature all along the length of the tube. How much would the bulk temperature increase over a 3 m length of the tube? (12 Marks)

. ***May/June 2010***

9 Water at 25°C flows through a tube of 50 mm diameter. Determine the flow rate that will result in a Reynolds number of 1600. The tube is provided with a nichrome heating element on its surface and receives a constant heat flux of 800 W/m length of the tube. Determine the average heat transfer coefficient between the water and the tube wall, assuming fully developed conditions. Also determine the length of the tube for the bulk temperature of water to rise from 25°C to 50°C. (12 M) ***December 2010***

10. Air stream at 27°C moving at 0.3 m/sec across 100 W incandescent bulb glowing at 127°C. If the bulb is approximated by a 60 mm diameter sphere, estimate the heat transfer rate and the percentage of power lost due to convection. Use correlation Nu = 0.37 $R_{eD}^{0.6}$. (08 Marks) ***December 2010***

11 Air at 0^{0}K and 20 m/s flows over a flat plate of length 1.5 m, that is maintained at 50^{0}C. Calculate the average heat transfer co-efficient over the region where flow is laminar. Find the average heat transfer co-efficient and the heat loss for the entire plate per unit width. ***(12 mks) December 2012***

12 Air at -20^{0}C and 30 m/s, flows over a sphere of diameter 25mm, which is maintained at 80^{0}C. calculate the heat loss from sphere. ***(8 mks) December 2012***

13.With the help of dimensional analysis derive expression which relates Reynoldsnumber, Nusselt number and prandtl number. ***10M.(Dec 2011)***

14. Air at standard conditions of 760 mm of hg at 200C flows over flat plateat 3 m/sec. The plate is 50 cms x 25 cms . Find the heat lost per hour if air flow is parallel to 50 cms side of the plate. If 25 cms side is kept parallel to air flow , what wil be the effect on heat transfer? Temperature of plate is 1000C.

: ***10M (Dec 2011)***

15. Define clearly and give expression for i) Reynolds number ii) Prandtl number iii) Nusselt number iv) Stanton number. ***10M (june/july 2011)***

16 50 kg water per minute from 300C and 500C by passing through a pipe of 2 cm diameter. The pipe is heated by condensing the steam on its surface at 1000C. Find the length of pipe required. Take for water at 900C, ṗ =965 kg/m3, K=0.585W/mK, Cp=4200 J/ Kg0C, γ=0.045m2/hr. 10M (june/july 2011)

17.Air at temperature of 200C flows through rectangular duct with velocity of 10 m/s. The duct is 30 cm x 20 cm in size and air leaves at 340C . find the heat gain by air when it is passed through 10 m long duct. . 10M (june/july 2011

18) For flow over flat plate, discuss concepts of velocity and thermal boundary layer with sketches. **(04 Marks)june2015**

19) Air at a free stream temperature T∞ and velocity U∞ flows over a flat plate maintained at a constant temperature TW. Dimensions of the flat plate is 50 cm × 25 cm. Compare the heat transfer co-efficient when the flow direction is along 50 cm side and 25 cm side. Assume laminar flow over entire plate.

(06 Marks) **june2015**

20) Hot air at atmospheric pressure and 80oC enters an 8 m long uninsulated square duct of cross section 0.2m × 0.2 m that passes through the attic of a house at a rate at 0.15 m3/s. The duct is observed to be nearly isothermal at 60oC. Determine the exit temperature of the air and the rate of heat loss from the duct to the attic space. (10 Marks) **june2015**

UNIT – 6

Heat Exchangers: Classification of heat exchangers; overall heat transfer coefficient, fouling and fouling factor; LMTD, Effectiveness-NTU methods of analysis of heat exchangers. Numerical problems. **06 Hours**

1. Derive an expression for the LMTD of a parallel flow heat exchanger. ***jun/jul 2013 (08M)***

2. Define effectiveness and NTU of a heat exchanger , Give their equation. . ***jun/jul 2013 (04M)***

3 .A tubular heat exchanger consists of 200 tubes each 20 mm outer diameter and 5m length. Hot fluid flows inside the tube and cold fluid flow over it, but in opposite direction to that of hot fluid. The overall heat transfer coefficient based on OD is 320 W/m2-K, Determine the out let temperature of both fluid and total heat transfer using the data given bellow: Tm = 120^0C, Tci = 20^0C, m_h = 20 kg/s, m_c = 5 kg/s, Cp_h = 2000 J/kg-K, Cp_c = 4000 J/kg-K. ***jun/jul 2013 (08M)***

4. Derive an expression for effectiveness of parallel flow heat exchanger. . ***jun/jul 2013 (08M)***

~~**5.** Under what conditions LMTD and effectiveness methods are used in the design~~ of heat exchanger. . ***jun/jul 2013 (02M)***

6 Oil at 100^0C (Cp=3.6 kj/kg K) flows at rate of 30000 kg/hr and enters a parallel flow heat exchanger. Cooling water (Cp=4.62kj/kg K) enters heat exchanger at 10^0C at the rate of 50000kg/hr. The heat transfer area is $10m^2$ and u= $1000W/m^2K$. Calculate outlet temperature of oil and water.
jun/jul 2013 (10M)

7. A cross flow heat exchanger in which both fluids are unmixed is used to heat water with an engine oil. Water enters at 30°C and leaves at 85°C at a rate of 1.5 kg/s, while the engine oil . with Cp= 2.3 kJ/kg °K enter at 120°C with a mass flow rate of 3.5 kg/s. The heat transfer surface area is 30 m2 . Calculate the overall heat transfer co-efficient by using LMTD method . (10M)***June-july 2009***

8. Derive an expression for LMTD of a parallel flow heat exchanger. State the assumptions made. (08 Marks) ***May/June 2010***

9. Water to water heat exchanger of a counter flow arrangement has heating surface area of 2m2. Mass flow rates of hot and cold fluids are 2000 kg/hr and 1500 kg/hr respectively. Temperatures of hot and cold fluids at inlet are 85°C and 25°C respectively. Determine the amount of heat transferred from hot to cold water and their temperatures at the exit if the overall heat transfer coefficient U = 1400 W/m2K. (12 .Marks) ***May/June 2010***

10. Define effectiveness and NTU of a heat exchanger. Explain why minimum heat capacity value is used in the definition of effectiveness for the maximum possible rate of heat transfer. (04 Marks) ***December 2010***

11. Derive an expression for LMTD in case of parallel flow heat exchanger stating the assumptions made. (08 Marks) ***December 2010***

12. A counter flow heat exchanger is employed to cool 0.55 kg/sec (Cp = 2.45kJ/kgK) of oil from 115°C to 40°C by the use of water. The inlet and outlet temperature of cooling water are 15°C and 75°C respectively. The overall heat transfer coefficient is expected to be 1450 W/m2°C. Using NTU method, calculate the following: i) The mass flow rate of water. ii) The effectiveness of heat exchanger .iii)The surface area required(08 Marks)
. ***December 2010***

13. Derive an expression for LMTD for a parallel flow heat exchanger.(10 Marks) ***2009 June-july***

14 Derive a expression for the logarithmic mean temperature difference (LMTD) for a parallel flow heat exchanger. ***(12 mks) December 2012***

15. A cross flow heat exchanger, with both fluids unmixed, has an area of $8.4m^2$, is used to heat air (Cp= 1005 J/kgk) with water (Cp= 4180 J/kgk). Air enters at 15^0C, at a rate of 2 Kg/s. while water enters at 90^0C at a rate of 0.25 Kg/s. The overall heat transfer co-efficient is 250 W/m^2k. calculate exit temperature of both fluids and the heat transfer, using effectiveness ----NTU method. . ***(8 mks) December 2012***

16. Derive an expression for LMTD for counter flow heat exchanger. State the assumptions made. ***10M.(Dec 2011)***

17. An oil cooler consist of straight tube of 2cms OD and 1.5 cm ID enclosed with in a pipe and co centric with it. The external pipe is well insulated .the oil flows through the tube at 0.05kg/sec (Cp =2KJ/kg0C) and cooling fluid flows in hte annulus in opposite direction at the rate of 0.1 kg/sec (Cp =4KJ/kg0C). The oil enters the cooler at 1800C and leaves at 800C while cooling liquid enters the cooler at 300C.Calculate the length of the pipe required if heat transfer coefficient from oil to tube surface is 1720 W/m20C and from metal surface to coolant is 3450 W/m20C. Neglect he resistance of tube wall. ***10M (Dec 2011)***

18. Give the classification of heat exchangers with relevant sketches. .
10M (june/july 2011)

19. With proper assumptions derive an expression for LMTD for a parallel flow heat exchanger. . ***10M (june/july 2011)***

20.A heat exchanger has an effectiveness of 0.5 when the flow is counter and the thermal capacity of one fluid twice that of the other fluid. Calculate the effectiveness of the exchanger if the direction of flow of one fluids is reversed with the same mass flow rate. ***10M (june/july 2011)***

21) Derive an expression for LMTD for counter flow heat exchanger. State the assumptions made**.(10 M) june2015**

22) 8000 kg/hr of air at 105oC is cooled by passing it through a counter flow heat exchanger. Find the exit temperature of air if water enters at 15oC and flows at a rate of 7500 kg/hr. The heat exchanger has heat transfer area equal to 20 cm2 and overall heat transfer co-efficient corresponding to this area is 145 W/m2-k . Take Cp of air = 1 KJ/kg-k and that of water (Cpw) = 4.18 KJ/kg-K**(10 M)june2015**
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UNIT – 7Condensation And Boiling: Types of condensation (discussion only) Nusselt's theory for laminar condensation on a vertical flat surface; use of correlations for condensation on vertical flat surfaces, horizontal tube and horizontal tube banks; Reynolds number for condensate flow; regimes of pool boiling, pool boiling correlations. Numerical problems. Mass transfer definition and terms used in mass transfer analysis, Ficks First law of diffusion (no numericals). **07 Hours**

1. With a neat sketch, discuss the different regimes of pool boiling.
   jun/jul 2013 (06M)
2. Distinguish between Film condensation and drop wise condensation.
   jun/jul 2013 (06M)
3. Determine the average heat transfer coefficient and the total condensation rate for air free saturated steam at 65^0C condenses on the outer surface of a 2.5 cm OD, 3m long vertical tube maintained at a uniform temperature of 35^0C by the flow of cooling water through the tube. If the tube is made horizontal, what will be the above values? Comment on results.
   .jun/jul 2013 (08M)
4. With a neat sketch, explain the regions of pool boiling. **(08M) Jun 2013**
5. State and explain Fick's law of diffusion. **(04M) Jun 2013**

6. Dry saturated steam at atmosphere pressure condenses on a vertical tube of diameter 5cm and length 1.5m. If the surface is maintained 80^0C, determined the heat transfer rate and the mass of steam condensed per hour.

jun/jul 2013 (08M)

7 Clearly explain the regions of pool boiling with a neat sketch. **(06M) Jun 2009**

8. Define i) Mass concentration, ii) Molar concentration **(04M) Jun 2009**

9. Air free saturated steam at a temperature of 65°C (p = 25.03kPa) condenses on a vertical outer surface of a 3m long vertical tube maintained at a uniform temperature of 35°C. Assuming film condensation, calculate the average heat transfer co-efficient over the entire length of the surface. Calculate the average heat transfer co-efficient and rate of condensate flow (taking the data same as for a vertical tube) for a horizontal tube of 2.5cm outer diameter. **(10M) Jun 2009**

10. Distinguish between the nucleate boiling and film boiling. **(06M) Jun 2010**

11. State and explain the Fick's law of diffusion. ***(04 Marks) May/June 2010***

12. A vertical plate 3()cmx30cm, is exposed to steam at atmospheric pressure. The plate temperature is 98°C. Calculate the heat transfer and the mass of steam condensed per hour. ***(10 Marks) May/June 2010***

13. Explain :

i) Filmwise condensation and dropwise condensation.

ii) Subcooled boiling and saturated boiling. **(*06 Marks) December 2010***

14. A square array of 400 tubes 15 mm outer diameter is used to condense steam at atmospheric pressure. The tube walls are maintained at 88°C by a coolant flowing through the tubes. Calculate the amount of steam condensed per hour per unit length of the tubes. ***(08 Marks) December 2012***

15. Saturated steam at 65^0C condenses on a vertical tube with an outer diameter of 25mm, which is maintained at 35^0C. Determine the length of tube needed, if the condensate flow needed is 6×10^{-3}kg/s. ***(10 mks) December 2012***

17. Water at atmospheric pressure and saturation temperature is boiled in a 250mm diameter, polished stainless steel pan, which is maintained at 116^0C. calculate the heat flux and the evaporation rate. ***(10 mks) December 2012***

18. State and explain Ficks law of diffusion. . ***10M (Dec 2011)***

19. Distinguish between the nucleate boiling and film boiling . ***10M (Dec 2011)***

20.A vertical tube of 60 mm outside diameter and 1.2m long is exposed to steam at atmospheric pressure. The outer surface of the tube is maintained at a temperature of 500C by circulating cold water through the tube. Calculate the following: i) The rate of heat transfer to the coolant ii) The rate of condensation of steam. ***10M.(Dec 2011)***

21. With neat diagram explain the regimes of pool boiling. ***10M (june 2011)***

22. With proper notations and sketches define Ficks law of diffusion.

. ***10M (june/july 2011)***

23.A vertical cooling fin approximates a flat plate of 40 cm height and is exposed to saturated steam at 1000C(hfg= 2257kJ/kg). The fin is maintained at a temperature of 900C calculate,i) Thickness of film at bottom of fin ii) Average heat transfer coefficient iii) Heat transfer rate after in corporating Mc Adams correction, Take the following properties ṗ =965.3 kg/m3, K=0.68W/mK, Cp=4200 J/ Kg0C, µ=3.153x10-4kg/ ms. . ***10M (june/july 2011)***

24) With a neat diagram, explain the typical boiling curve for water at 1 atm pressure. . **(08 Marks)june2015**

25) State and explain Fick’s law of diffusion. **(04 Marks)june2015**

26) A tube of 15 mm outside diameter and 1.5 m long is used for condensing steam at 40 KPa. Calculate the average heat transfer coefficient when the tube is: i) Horizontal ii) vertical and its surface temperature is mentioned at 50^oC.

(08 Marks)june2015

UNIT – 8

Radiation Heat Transfer: Thermal radiation; definitions of various terms used in radiation heat transfer; Stefan-Boltzman law, Kirchoff’s law, Planck’s law and Wein’s displacement law. Radiation heat exchange between two parallel infinite black surfaces, between two parallel infinite gray surfaces; effect of radiation shield; intensity of radiation and solid angle Lambert’s law; radiation heat exchange between two finite surfacesconfiguration factor or view factor. Numerical problems.

07 Hours

1. Explain i) Steam Boltzman law, ii) Kirchoff s law iii) Plank's law, iv) Wein's displacement law .v) Radiation shield.

(10 Marks) June-july 2009

2 Two large parallel plates with € = 0.5 each, arc maintained at different temperatures and are exchanging heat only by radiation. Two equally large radiations shields with surface emissivity 0.05 are introduced in parallel to the plates. Find the percentage reduction in net radiative heat transfer.

June-july 2009

3. With reference to thermal radiation, explain the following terms:

i) Black body and gray body ii) Specular and diffuse surface iii) Radiosity and irradiation. ***(06 Marks) May/June 2012***

4. Two parallel black plates 0.5mxlm are spaced 0.5m apart. One plate is maintained at 1000°C and the other at 500°C. What is the net radiant heat exchange between the two plates? (06 Marks) ***May/June 2010***

For a black body enclosed in a hemispherical space show that emissive power of the black body is n time the intensity of radiation. ***(08 Marks) Dec 2010***

5. State and explain:

i) Kirchoff s law. ii) Planck's law. ,iii) Wein's displacement law. iv) Lambert's cosine law. ***08 Marks) December 2010***

6. Explain briefly the concept of a black body.
(04 Marks) December 2010

7. Two very large parallel planes, with emissivities 0.3 and 0.8 exchange heat. Find the percentage reduction in heat transfer when a polished aluminium radiation shield (€= 0.04) is placed between them. ***May/June 2010***

8. Define i) Black body ii) Plank's Law iii) Wein displacement law iv) Lambert's law ***June-july 2013***

9. Prove that emissive power of a black body in a hemispeherical enclosure is times the intensity of radiation. ***June-july 2013***

10. Calculate net heat radiation (exchange) per m^2 for two large parallel plates maintained at 800^0C and 300^0C. The emissivities of two pltes are 0.3 and 0.6 repectively. ***June-july 2013***

11) State and prove the kirchoff,s law of radiation .
June-july 2013

12. With usual notations prove that the emissive power of a diffuse surface is times its intensity. ***June-july 2013***

13. Two large parallel plates of equal areas at temperature of 150^0C and 40^0 C, While their emissivity's are 0.6 and 0.7 respectively. If a radiation shield of emissivity 0.04 is insered in between the plates, Estimate the percentage reduction in heat exchange by radiation. ***June-july 2013***

14.State and prove kirchoff s law of radiation. ***(6 mks) December 2012***

15. Two large parallel plates with emissivities 0.5 and 0.8 are maintained at 800K and 600K respectively. A radiation shield having an emissivity of 0.1 on one side and 0.05 on other side is placed in between. Calculate ehe heat transfer per unit area with and without the radiation shield. ***(8 mks) December 2012***

16. Determine the view factors from the base of a cube to each of its surfaces. . (***6 mks)December 2012***

17. Explain briefly the concept of a balck body. ***10M.(Dec 2011)***

18. State and explain,i) kirchoffs law ii) Plancks Law iii) Weins displacement law iv) lamberts cosine law. ***10M.(Dec 2011)***

19. Calculate the net radiant heat exchange per unit area for two large parallel plates at temperature of 4270C and 270C respectively. έ hot plate=0.9 . έ coldplate=0.6. if a polished aluminium shiekd is placed between them . find the percentage reduction in heat transfer. . έ shield=0.0 ***10M (Dec 2011***)

20. Clearly define: i) Black body ii) Plancks law iii) Weins displacement iv) Lamberts law v) View factor vi) radiation shield. ***10M (june/july 2011***

21. It is desired to calculate the net radiant heat exchange between the floor of a furnace 4m x 2m and a side wall 3m x 2m . The emissivity of the floor material is 0.63 and that of the side wall material is 0.2 . if the temperature of the floor and side wall are 6000C and 4000C respectively. calculate net heat exchange between them. ***10M (june/july 2011)***

22. Two large parallel palnes with emmisivity 0.6 are at 900K and 300K. A radiation shield with one side polished and having emmisivity of 0.05 and the other side unpolished with emmisivity of 0.4 is proposed to be used between them which side of should face the hotter plane, if the temperature of the shield is to be kept minimum? Justify your answer. ***10M (june/july 2011)***

23). Explain briefly concept of black body with an example. **(02 Marks)june2015**

24**)**. State and explain: (i) Planck's law (ii) Kirchoff's law (iii) Wiens displacement law. (iv) Lambert's cosine law. (**08 Marks)june2015**

25**)**. Two parallel plates, each of 4m^2 area, are large compared to a gap of 5 mm separating them. One plate has a temperature of 800 K and surface emissivity of 0.6, while the other has a temperature of 300 K and a surface emissivity of 0.9. Find the net energy exchange by radiation between them. If a polished metal sheet of surface emissivity 0.1 on both sides is now located centrally between the two plates, what will be its steady state temperature? How the heat transfer would be altered? Neglect the convection and edge effects if any. Comment upon the significance of this exercise. .
. **(10 Marks)june2015**

Sixth Semester B.E. Degree Examination, Dec.2019/Jan.2020
Heat Transfer

Time: 3 hrs. Max. Marks: 80

Note: ***1. Answer any FIVE full questions, choosing ONE full question from each module.***
2. Use of Heat transfer data hand book is permitted.

Module-1

1 a. Elaborate basic laws governing modes of heat transfer. **(06 Marks)**

b. Explain what do you mean by thermal contact resistance. **(02 Marks)**

c. The surface of a spherical container with 0.4 m outer diameter is at –195°C. Two layers of insulation each of 2.5 cm thickness is added. The thermal conductivities of the materials are 0.004 and 0.03 W/mK. The contact resistances are each of 5×10^{-4} m^2°CW. The outside is exposed to air at 30°C with a convection coefficient of 16 W/m^2K. Determine the heat gain and the temperatures at various surfaces and also the drops due to contact resistance. **(08 Marks)**

OR

2 a. Explain the types of boundary conditions involved in heat transfer problems. **(06 Marks)**

b. Write down the general heat conduction equation in (i) cylindrical coordinate system (ii) spherical coordinate system. **(02 Marks)**

c. A composite slab is made of three layers 15 cm, 10 cm and 12 cm thickness. The first layer is of material with K = 2.5 W/mK, and occupies 60% of area and the rest is of K = 1.45 W/mK. The second layer is made of material 12.5 W/mK for 50% area and remaining is of material with K = 18.5 W/mK. The third layer is of single material with K = 0.76 W/mK. The slab is exposed to warm air at 26°C and cold air at –20°c on the other side. The convective coefficients are 15 and 20 W/m^2K on the inside and outside respectively. Determine heat flow and interface temperatures. **(08 Marks)**

Module-2

3 a. Derive the equation of temperature distribution for long fin with usual notations. **(08 Marks)**

b. Circumferential fins of constant thickness of 1 mm are fixed on a 50 mm pipe at a pitch of 9 mm. The fin length is 20 mm. The wall temperature is 130°C. The K = 210 W/mK. The convective coefficient is 50 W/m^2K. Determine heat flow and effectiveness. **(08 Marks)**

OR

4 a. Derive equation of temperature distribution using lumped parameter model. **(08 Marks)**

b. A concrete wall initially at 30°C is exposed to gases at 900°C with h = 85 W/m^2K. The thermal diffusivity is 4.92×10^{-7} m^2/s. the K of material is 1.28 W/mK. Determine the temperature of the surface and temperatures at 1 cm depth and also 5 cm depth after 1 hr. Also estimate the heat flow at the surface at the instant. **(08 Marks)**

Module-3

5 a. Derive solution to differential equation for steady two dimensional conduction with usual notations. **(08 Marks)**

b. A plate 1m × 2m side has both its 2m sides and one 1m side at 100°C. The temperature along the fourth side is given by $T = 400\sin\left(\frac{\pi x}{1}\right) + 100$ where x is in m from the corner and t is in °C. Determine temperature taking 1m on x direction and 2m on y direction at following locations (i) (0.25, 0.5) (ii) (0.25, 1) (iii) (0.5, 1.5) (iv) (0.5, 2.0) **(08 Marks)**

OR

6 a. Define and explain the following:
i) Black body
ii) Shape factor
iii) Wein's displacement law
iv) Kirchoff's law **(08 Marks)**

b. Two large parallel planes are at 1000 K and 600 K. Determine the heat exchange per unit area.
(i) If surfaces are black
(ii) If the hot one has an emissivity of 0.8 and cooler one 0.5
(iii) If a large plate is inserted between these two, having emissivity of 0.2. **(08 Marks)**

Module-4

7 a. Explain formation of hydrodynamic and thermal boundary layers. **(08 Marks)**

b. A flat heater of circular shape of 0.2 m dia with a heat generation of 1.2 KW/m^2 is kept in still air at 20°C with heated surface facing downward and inclined at 15° to the horizontal. Determine heat transfer coefficient. **(08 Marks)**

OR

8 a. Write the importance of the following:
(i) Grashoff number
(ii) Prandtl number
(iii) Reynolds number
(iv) Stanton number **(08 Marks)**

b. Nitrogen at –20°C gets heated as it flows through a pipe of 25 mm dia at a flow rate of 13.72 kg/hr at 1 atm pressure. Determine the value of pipe temperature at the exit where pipe is heated with uniform heat flux of 500 W/m^2 and pipe is 4m long. Take Cp of nitrogen as 1030 J/kgK. **(08 Marks)**

Module-5

9 a. Sketch and explain regimes of pool boiling. **(08 Marks)**

b. Water at atmospheric pressure is boiling on a brass surface heated from below. If the surface is at 108°C, determine the heat flux and compare the same with critical heat flux. **(08 Marks)**

OR

10 a. Derive CMTD for parallel flow heat exchanger. **(08 Marks)**

b. In a shell and tube heat exchanger/condenser, the tube bank is 10 rows deep with ID of tube 20 mm and OD 25 mm. the tubes are arranged in square array of 50 mm pitch. Water flows across the tubes with V = 0.5 m/s. Sea water flows inside with 1 m/s. The water is cooled from 50°C to 30°C and sea water temperature changes from 15°C to 25°C. Assuming same properties for both side water, determine overall heat transfer coefficient. The tubes are of brass with K = 60.6 W/mK. Assume tube length of 4m. **(08 Marks)**

Sixth Semester B.E. Degree Examination, Aug./Sept.2020
Heat Transfer

Time: 3 hrs. Max. Marks: 80

Note: 1. Answer any FIVE full questions, choosing ONE full question from each module.
2. Use of Heat and Mass Transfer data handbook is permitted.

Module-1

1 a. Derive the 3-D heat conduction equation in Cartesian coordinate system for an isotropic material. Also write special forms of 3-D heat conduction equation. **(08 Marks)**

b. A furnace wall is made up of three layers of thickness 250 mm, 100 mm, 150 mm with thermal conductivities of 1.65, K, 9.2 W/m-K respectively. The inside is exposed to gases at 1250°C with convection coefficient of 25 W/m^2-K and outside surface is exposed to air at 25°C with convection coefficient of 12 W/m^2-K, inside surface is maintained at 1100°C. Determine:
(i) The unknown thermal conductivity
(ii) Overall heat transfer coefficient
(iii) All surface temperatures. **(08 Marks)**

OR

2 a. Explain the modes of heat transfer with corresponding governing laws. **(06 Marks)**

b. Explain the three kinds of boundary conditions to solve conduction problems. **(04 Marks)**

c. A wall of steam boiler furnace is made of layers of fire clay of thickness 12.5 cm (K_1 = 0.28 + 0.00023T W/m°C) and red brick of 50 cm (K_2 = 0.7 W/m°C) where T is in °C. The inside surface temperature of fire clay is 1100°C and outside brick wall temperature is 50°C. Calculate the amount of heat loss per unit area of the furnace wall and the temperature at the interface. **(06 Marks)**

Module-2

3 a. What do you mean by critical thickness of insulation? Derive an expression for critical thickness of insulation for cylinder. **(05 Marks)**

b. In a thermal conductivity measuring experiment two identical long rods are used. One rod is made of aluminium (K = 200 W/m-K). The other rod is specimen. One end of both the rods is fixed to a wall at 100°C, while the other end is suspended in air at 25°C. The steady temperature at the same distance along the rods were measured and found to be 75°C on aluminium and 60°C on specimen rod. Find thermal conductivity of the specimen. Assume that the fin is insulated at the tip. **(05 Marks)**

c. Show that the temperature distribution under lumped analysis is given by, $\frac{T - T_\infty}{T_i - T_\infty} = e^{-Bi.Fo}$

where T_i is the initial temperature and T_∞ is the surrounding temperature. **(06 Marks)**

OR

4 a. What is the main purpose of fins? Define fin efficiency and fin effectiveness. **(04 Marks)**

b. What are Heisler charts? Explain their significance in solving transient conduction problems. **(04 Marks)**

c. A 12 mm diameter mild steel sphere at 540°C is exposed to cooling air flow at 27°C and heat transfer coefficient of 114 W/m2-K. Find:
   (i) The time required to cool the sphere from 540°C to 95°C
   (ii) Instantaneous heat transfer rate, two minutes after start of cooling
   (iii) Total heat transferred from the sphere during first two minutes.
   Properties of mild steel are: $\rho = 7850$ kg/m^3, C = 475 J/kg-K and $\alpha = 0.045$ m^2/hr. **(08 Marks)**

Module-3

5 a. Why numerical methods are preferred over analytical methods? List the numerical methods which are used in solving heat conduction problems. **(04 Marks)**

b. The boundary temperatures of a thin plate are as shown in Fig.Q5(b). Determine the temperature at the centre of the plate.

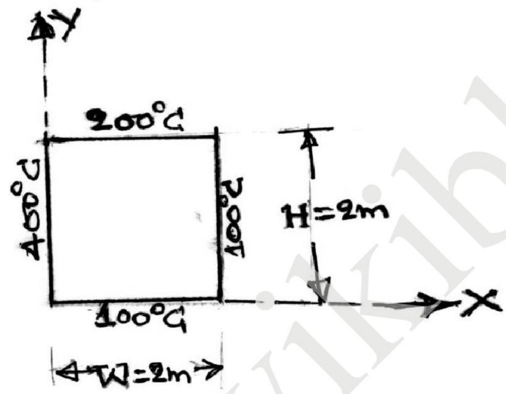

Fig.Q5(b) **(06 Marks)**

c. Explain:
   (i) Kirchhoff's law
   (ii) Plank's law
   (iii) Wien's displacement law **(06 Marks)**

OR

6 a. How is Laplace equation for 2D heat conduction approximated to the finite difference equations? **(08 Marks)**

b. Calculate the net radiant heat exchange per unit area for two large parallel plates at temperature of 427°C and 27°C respectively. Take emissivity of hot plate and cold plates are 0.9 and 0.6 respectively. If a polished aluminium shield is placed between them, find percentage reduction in the heat transfer. Take emissivity of shield as 0.4. **(08 Marks)**

Module-4

7 a. With the help of dimensional analysis obtain the fundamental relation between dimensionless numbers required for
   (i) Forced convection
   (ii) Natural convection. **(10 Marks)**

b. Water at a velocity of 1.5 m/s enters a 2 cm diameter heat exchanger tube at 40°C. The heat exchanger tube wall is maintained at a temperature of 100°C. If the water is heated to a temperature of 80°C in the heat exchanger tube, find the length of the exchanger tube required. **(06 Marks)**

OR

8 a. Define an explain the physical significance of the following dimensionless numbers:
   (i) Grashoff number
   (ii) Reynolds number **(04 Marks)**

b. For fluid flow over a flat plate, sketch (i) Velocity boundary layer (ii) Thermal boundary layer. Clearly mention salient points on the figure. **(04 Marks)**

c. A tube of 0.036 m OD and 40 cm length is maintained at a uniform temperature of 100°C. It is exposed to air at a uniform temperature of 20°C. Determine the rate of heat transfer from the surface of the tube when (i) the tube is vertical (ii) the tube is horizontal. **(08 Marks)**

Module-5

9 a. What is the importance of NTU effectiveness method? Derive an expression for the effectiveness of a parallel flow heat exchanger. **(08 Marks)**

b. Sketch pool boiling curve for water and explain the various regimes in boiling heat transfer. **(08 Marks)**

OR

10 a. List the assumptions made in Nusselt's theory of laminar film condensation on a plane vertical surface. **(04 Marks)**

b. Saturated steam at 80°C condenses as a film on a vertical plate at a temperature of 70°C. Calculate the average heat transfer coefficient and the rate of steam condensation per hour. Assume that the latent heat of vaporization at 80°C as 2309 kJ/kg. **(06 Marks)**

c. An oil cooler for a large diesel engine is to cool engine oil from 60 to 45°C using sea water at an inlet temperature of 20°C with a temperature rise of 15°C. The design load Q = 140 KW and the mean overall heat transfer coefficient based on the outer surface area of the tubes is 70 W/m^2°C. Calculate the heat transfer surface area for single pass counter flow and parallel flow arrangement. **(06 Marks)**

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Sixth Semester B.E. Degree Examination, June/July 2019
Heat Transfer

Time: 3 hrs. Max. Marks: 80

Note: 1. Answer any FIVE full questions, choosing ONE full question from each module.
2. Use of heat transfer data hand book and steam tables are permitted.

Module-1

1 a. State the laws governing three basic modes of heat transfer. **(06 Marks)**

b. Derive the general three-dimensional conduction equation in Cartesian coordinates and state the assumptions made. **(10 Marks)**

OR

2 a. Derive an expression for the temperature distribution through the plane wall with uniform thermal conductivity. **(06 Marks)**

b. A metal [K = 45 W/m°C] steam pipe of 5 cm inside diameter and 6.5 cm outside diameter is lagged with 2.75 cm thickness of high temperature high insulation having thermal conductivity 1.1 W/m°C. convective heat transfer coefficients on the inside and outside surfaces are 4650 W/m^2K and 11.5 W/m^2K respectively. If the steam temperature is 200°c and the ambient temperature is 25°C. Calculate:

i) Heat loss per metre length of pipe
ii) Temperature at the interfaces
iii) Overall heat transfer coefficient to inside and outside surfaces. **(10 Marks)**

Module-2

3 a. Derive an expression for critical thickness of insulation for a cylinder. **(06 Marks)**

b. The handle of a ladle used for pouring molten metal at 327°C is 30 cm long and is made of 2.5 cm × 1.5 cm mild steel bar stock [K = 43 W/mK]. In order to reduce grip temperature, it is proposed to make a hallow handle of mild steel plate 0.15 cm thick to the same rectangular shape. If the surface heat transfer coefficient is 14.5 W/m^2K and the ambient temperature is 27°C, estimate the reduction in the temperature of grip. Neglect the heat transfer from inner surface of the hallow shape. **(10 Marks)**

OR

4 a. What is lumped system analysis? Derive the temperature variation using lumped parameter analysis. **(06 Marks)**

b. An iron sphere of diameter 5 cm is initially at a uniform temperature of 225°C. It is suddenly exposed to an ambient at 25°C with convection coefficient of 500 W/m^2K.

i) Calculate the centre temperature 2 minute after the start of exposure.
ii) Calculate the temperature at a depth of 1 cm from the surface after 2 minute of exposure.
iii) Calculate the energy removed from the sphere during this period.

Take thermo physical properties of iron sphere K = 60 W/mK, ρ = 7850 kg/m^3, C = 460 J/kg, $\alpha = 1.6 \times 10^{-5}$ m^2/s. **(10 Marks)**

Module-3

5 a. Explain the three types of boundary conditions are applied in finite difference representations. **(06 Marks)**

b. Derive the relation between normal intensity and emissive power. **(10 Marks)**

OR

6 a. Explain:

i) Stefan Boltzman law

ii) Kirchoff's law

iii) Planks law **(06 Marks)**

b. Two large parallel plates with $\in = 0.5$ each, are maintained at different temperatures and are exchanging heat only by radiation. Two equally large radiations shields with surface emissivity 0.05 are introduced in parallel to the plates. Find the percentage reduction in net radiative heat transfer. **(10 Marks)**

Module-4

7 a. Explain the physical significance of:

(i) Prandtl number (ii) Reynolds number (iii) Nusselt number **(06 Marks)**

b. Air at 1 atm pressure and temperature 25°C flowing with a velocity 50 m/s crosses an industrial heater made of long solid rod of diameter 20 mm. The surface temperature of the heater is 457°C. Determine the allowable electrical power density (W/m^3) within the heater per meter length. **(10 Marks)**

OR

8 a. A circular plate of 25 cm diameter with both surfaces maintained at a uniform temperature of 100°C is suspended horizontally in atmospheric air at 20°C. Determine the heat transfer from the plate. **(10 Marks)**

b. Obtain the fundamental relationship between Nusselt, Prandtle and Reynolds number using Buckingham's π - theorem for forced convection heat transfer. **(06 Marks)**

Module-5

9 a. Derive an expression for LMTD for a parallel flow heat exchanger. **(06 Marks)**

b. A refrigerator is designed to cool 250 kg/hr of hot fluid of specific heat 3350 J/kg°C at 120°C using a parallel arrangement 1000 kg/hr of cooling water is available for cooling purposes at a temperature of 10°C. If the overall heat transfer coefficient is 1160 $W/m^2{}^\circ C$ and the surface area of the heat exchanger is 0.25 m^2. Calculate the outlet temperature of the cooled liquid and water and also the effectiveness of the heat exchanger and rate of heat transfer. **(10 Marks)**

OR

10 a. Sketch and explain boiling curve. **(06 Marks)**

b. The outer surface of a vertical tube 80 mm in outer diameter and 1m long is exposed to saturated steam at atmospheric pressure. The tube surface is maintained at 50°C by flow of water through the tube. What is the rate of heat transfer to coolant and what is the rate of condensation of steam? **(10 Marks)**

Sixth Semester B.E. Degree Examination, Dec.2018/Jan.2019
Heat Transfer

Time: 3 hrs. Max. Marks: 80

Note: 1. ***Answer FIVE full questions, choosing one full question from each module.***
2. ***Use of heat transfer data hand book and steam tables are permitted.***

Module-1

1 a. Explain three modes of heat transfer with their basic laws. **(06 Marks)**

b. The inner wall of the furnace is made of fire brick of thickness 115 mm and the outer wall is made of red brick of thickness 230 mm. The temperature of the inside furnace is 685°C and the temperature of outside surface of red brick is 121°C under steady state condition to reduce the heat loss a layer of Magnesia insulation of thickness 50 mm is added on the outer surface of red brick after steady state condition is reached. The various temperature are measured as flame side of furnace 712°C junction between the fire brick and red brick is 655°C, junction between the red brick and Magnesia is 490°C outer surface Magnesia temperature is 77°C. Calculate the heat loss in first and second cases and find the percentage of heat loss reduction. Assume thermal conductivity of Magnesia is 0.085 W/m°C. **(10 Marks)**

OR

2 a. State the assumptions and derive general 3-dimensional heat conduction equation in Cartesian co-ordinates. **(08 Marks)**

b. A hollow sphere is made up of steel having thermal conductivity of 45 W/m°C. It is heated by means of a coil of resistance 100 Ω which carries a current of 5 amps. The coil is located inside a hallow space at the centre. The outer surface area of sphere is 0.2 m^2 and its mass 32 kg assuming density of the sphere material to be 8 gm/cc. Calculate the temperature difference between the inner and outer surface. **(08 Marks)**

Module-2

3 a. Derive an expression for the temperature distribution and heat flow for a pinfin, when the tip of the fin is insulated. **(08 Marks)**

b. A thin rod of copper K = 100 W/m°C, 12.5 mm in diameter spans between two parallel plates 150 mm apart. Air flows over the rod providing a heat transfer co-efficient of 50 $W/m^{2}°C$. The surface temperature of the plate exceeds the air by 40°C. Determine (i) The excess temperature at the centre of the rod over that of air and (ii) Heat lost from the rod in watts. **(08 Marks)**

OR

4 a. Show that the temperature distribution under lumped analysis is given by,

$$\frac{T - T_\infty}{T_i - T_\infty} = e^{-BiFo}$$

Where T_i = Initial temperature

T_∞ = Ambient temperature **(08 Marks)**

b. A 15 mm diameter mild steel sphere (K = 42 W/m°C) is exposed to coding air flow at 20°C resulting in the convective co-efficient h = 120 $W/m^{2}°C$. Determine the following:

(i) Time required to cool the sphere from 550°C to 90°C.
(ii) Instantaneous heat transfer rate for 2 mins after start of cooling.
(iii) Total energy transferred from the sphere during first 2 mins.

Take for mild steel S = 7850 kg/m^3, C_P = 475 J/kg°C, α = 0.045 m^2/hr **(08 Marks)**

Module-3

5 a. Explain three types of boundary conditions applied in Finite difference representations. **(09 Marks)**

b. Consider steady-state heat conduction in a square region of side 2b, in which energy is generated at a constant rate of $g \, w/m^3$. The boundary conditions for the problem are shown in Fig. Q5 (b). Write the finite difference equations for nodes 1, 3 and 5 in this Fig. Q5 (b) **(07 Marks)**

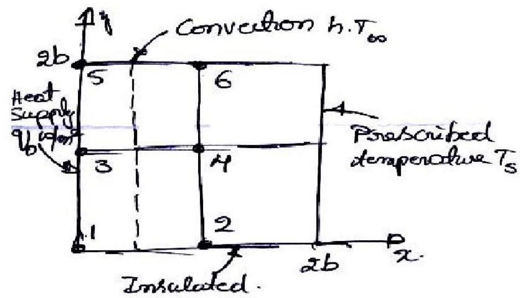


Fig. Q5 (b)

OR

6 a. State and explain : (i) Kirchoff's law (ii) Plank's law (iii) Wein's displacement law (iv) Lambert's cosine law. **(08 Marks)**

b. Two large parallel plots with emissivity 0.5 each are maintained at different temperatures and are exchanging heat only by radiation. Two equally large radiation shields with surface emissivity 0.05 are introduced in parallel to the plates. Find the percentage reduction in net radiative heat transfer. **(08 Marks)**

Module-4

7 a. With a diagram, explain velocity boundary layer and thermal boundary layer. **(08 Marks)**

b. Lubricating oil at a temperature of 60°C enters a 1 cm diameter tube with a velocity 3.5 m/s. The tube surface is maintained at 30°C. Calculate the tube length required to cool the oil to 45°C. Assume that the oil has the following average properties for the temperature range of this problem S = 865 kg/m^3, K = 0.14 W/m°K, C_P = 1.78 kJ/kgK and $\gamma = 9 \times 10^{-6}$ m^2/s. **(08 Marks)**

OR

8 a. Explain the significance of, (i) Reynold's number (ii) Prandtl number (iii) Nusselt number (iv) Stanton number. **(08 Marks)**

b. Calculate the convection heat loss from a radiator 0.5 m wide and 1 m high maintained at a temperature of 84°C in a room at 20°C. Treat the radiator as a vertical plate. **(08 Marks)**

Module-5

9 a. With assumptions, determine LMTD for counter flow heat exchanger. **(08 Marks)**

b. A parallel flow heat exchanger uses 1500 kg/hr of cold water entering at 25°C to cool 600 kg/hr of hot water entering at 70°C. The exit temperature on the hot side is required to be 50°C. Neglecting the effects of fouling make calculations for the area of heat exchanger. It may be assumed that the individual heat transform co-efficient on both sides are 1600 W/m^{2}K. Use LMTD and NTU approaches. **(08 Marks)**

OR

10 a. With a neat sketch, explain the different regimes of pool boiling. **(08 Marks)**

b. A vertical square plate $300m \times 300m$ is exposed to steam at atmospheric pressure. The plate temperature is 98°C. Calculate the heat transfer and the mass of steam condensed per hour. **(08 Marks)**

Sixth Semester B.E. Degree Examination, June/July 2018

Heat Transfer

Time: 3 hrs. Max. Marks: 80

Note: 1. Answer any FIVE full questions, choosing one full question from each module.
2. Use of Heat transfer data hand book, steam table are permitted.

Module-1

1 a. What do you mean by boundary condition of 1st, 2nd and 3rd kind? **(06 Marks)**

b. Explain briefly the mechanism of conduction, convection and radiation of heat transfer. **(06 Marks)**

c. A mild steel tank of wall thickness 20 mm is used to store water at 95°C. Thermal conductivity of mild steel is 45 W/m °C, and the heat transfer coefficient inside and outside the tank are 2850 W/m^2 °C and 10 W/m^2 °C respectively. If surrounding air temperature 20°C, calculate Rate of heat transfer per unit area of the tank. **(04 Marks)**

OR

2 a. Derive the general three dimensional heat conduction equation in Cartesian coordinate and state the assumption made. **(08 Marks)**

b. The wall of a house in cold region consists of three layers, an outer brick work 15 cm thick, the inner wooden panel 1.2 cm thick, the intermediate layer is insulator of 7 cm thick. The 'k' for brick and wood are 0.7 and 0.18 W/mK. The inside and outside temperature of wall are 21 and – 15°C. If insulation layer offer twice the thermal resistance of the brick wall, calculate (i) heat loss per unit area (ii) 'k' of insulator. **(08 Marks)**

Module-2

3 a. Derive the expression for critical thickness of insulation for cylinder. **(06 Marks)**

b. Differentiate between effectiveness and efficiency of fins. **(04 Marks)**

c. A rod [k = 200 W/mK] 5 mm in diameter and 5 cm long has its one end maintained at 100°C. The surface of the rod is exposed to ambient air at 25°C with convection heat transfer coefficient of 100 W/m^2K. Assuming other end is insulated. Determine (i) the temperature of rod at 20 mm distance from the end at 100°C (ii) Heat dissipation rate from the surface of rod (iii) Effectiveness. **(06 Marks)**

OR

4 a. Derive the expression for temperature variation and heat flow using Lumped Parameter Analysis. **(06 Marks)**

b. Explain significance of Biot and Fourier number. **(04 Marks)**

c. The average heat transfer coefficient for flow of 100°C air over a flat plate is measured by observing the temperature time history of a 3 cm thick copper slab exposed to 100°C air, in one test run, the initial temperature of slab was 210°C and in 5 min the temperature is decreased by 40°C. Calculate the heat coefficient for this case. Assume ρ = 9000 kg/m^3 ; C = 0.38 kJ/kgK , K = 370 W/mK. **(06 Marks)**

Module-3

5 a. Explain formulation of differential equation 1-D steady heat conduction. (06 Marks)
b. Explain different solution method used in numerical analysis of heat conduction. (06 Marks)
c. Explain applications and computation error of numerical analysis heat conduction. (04 Marks)

OR

6 a. Define (i) Blackbody (ii) Planks law (iii) Wein displacement law (iv) Lamberts law. (06 Marks)
b. Prove that emissive power of the black body in hemispherical enclosures in π terms of intensity of radiation. (06 Marks)
c. The temperature of black surface of 0.2 m^2 area is 540°C. calculate (i) the total rate of energy emission (ii) the intensity of normal radiation (iii) the wavelength of maximum monochromatic emission power. (04 Marks)

Module-4

7 a. Explain with neat sketches (i) Velocity Boundary layer (ii) Thermal boundary layer. (08 Marks)
b. Air flows over a flat plate at 30°C, 0.4m wide and 0.75m long with a velocity of 20m/s. Determine the heat transfer from the surface of plate assuming plate is maintained at 90°C.
Use $N_{UL} = 0.664\, R_e^{0.5}\, Pr^{0.33}$ for laminar
$N_{UL} = \left[0.036\, R_e^{0.8} - 0.836\right] Pr^{0.333}$ for turbulent. (08 Marks)

OR

8 a. Explain the physical significance of the following dimensionless number:
(i) Reynold's number (ii) Prandtl number (iii) Nusselt number
(iv) Stantor number. (06 Marks)
b. A stream pipe 5 cm in diameter is lagged with insulating material of 2.5 cm thick. The surface temperature is 80°C and emissivity of the insulating material surface is 0.93. Find the total heat loss by natural convection and radiation. The temperature of the air surrounding the pipe is 20°C. Also find the overall heat transfer coefficient. (10 Marks)

Module-5

9 a. Derive expression for LMTD for parallel flow heat exchanger and state the assumption made. (08 Marks)
b. Water enters a counter flow heat exchanger at 15°C flowing at a rate of 1300 kg/h. It is heated by oil [c_p = 2000 J/kgK] flowing at the rate of 550 kg/h with an inlet temperature of 94°C for an area 1 m^2 and overall heat transfer coefficient of 1075 W/m^2K. Determine the total heat transfer and outlet temperature of water and oil. (08 Marks)

OR

10 a. Explain different regimes of pool boiling with neat sketches. (08 Marks)
b. Draw saturated stream at a pressure of 2.0 bar condenses on the surface of vertical tube of height 1 m. The tube surface is kept at 117°C. Estimate the thickness of the condensate film and heat transfer coefficient at a distance of 0.2 m from the upper end of the tube. Assume the condensate film to be laminar. Also calculate the average heat transfer coefficient over the entire length of the tube. (08 Marks)

SAMPLE COPY OF HAND WRITTEN NOTES

MODULE-5

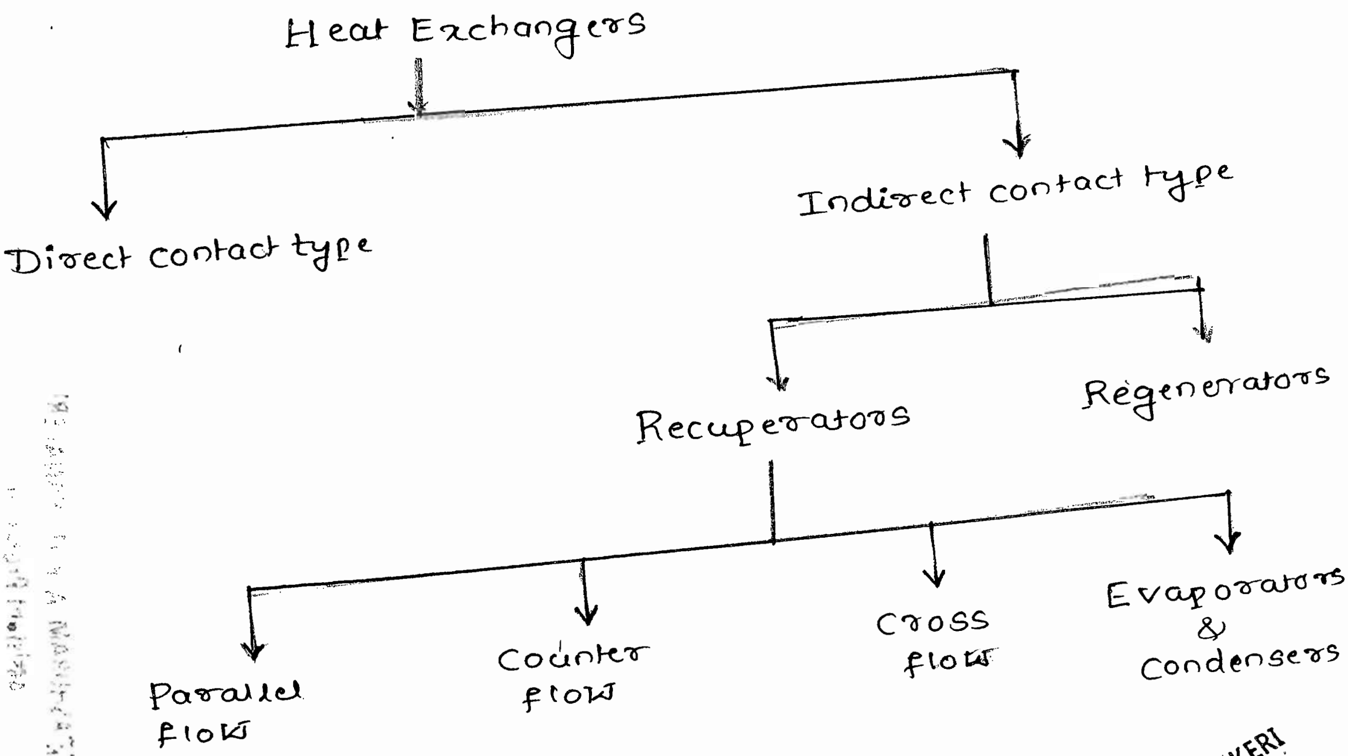
UNIT-9 HEAT EXCHANGER

Heat Exchangers are the device in which the exchange of heat takes place between two fluids flow through heat exchanger simulteneously with sperating wall between them. The fluid which recieves the heat is known as cold fluid. and fluid which loses the heat is known as hot fluid. the temperature of hot fluid decreases from inlet to outlet where as temperature of cold fluid. increases from inlet to outlet in a heat exchanger

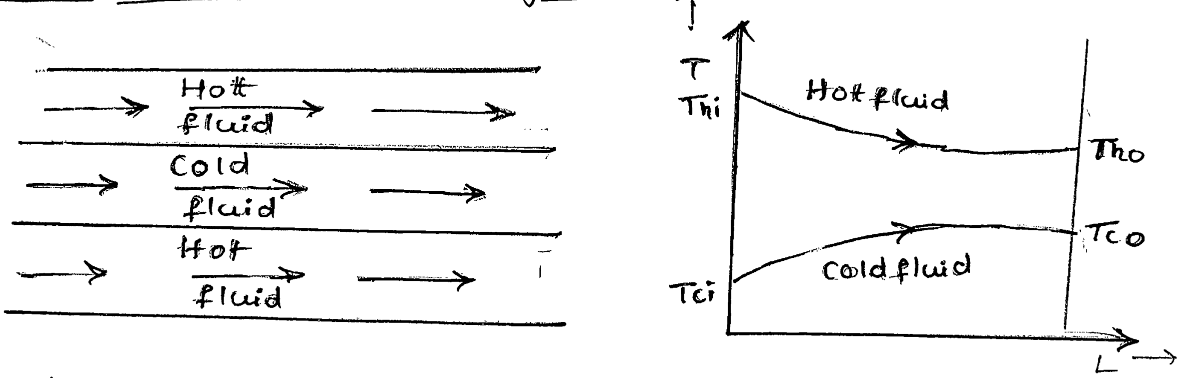
Ex: Air preheaters, Superheaters, Economisers, boilers and condensers

In Industries heat exchangers are employed in large no in plant such as chemical plant or oil plant.

Classification of Heat Exchangers:

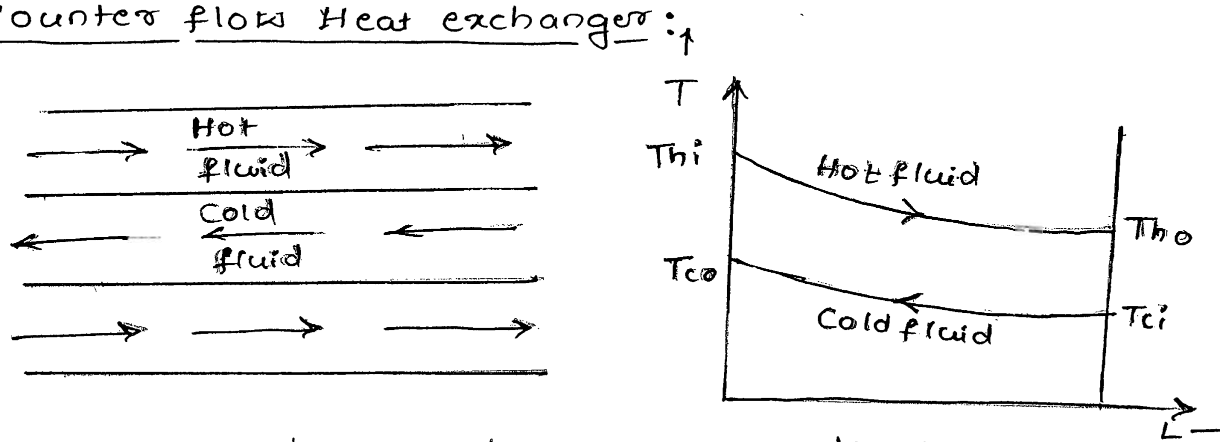


1> Parallel flow Heat Exchanger :



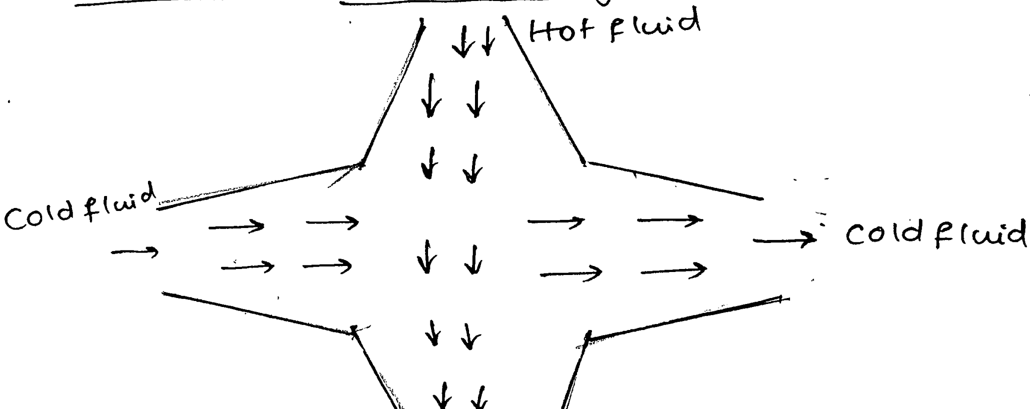
A parallel flow heat exchanger is one in which both hot & cold fluid flow in same direction the temperature distribution diagram for parallel flow heat exchanger is shown in above figure.

2> Counter flow Heat exchanger :



In counter flow heat exchanger the hot & cold fluid flow in opposite direction to each other. The temperature distribution diagram for a counter flow heat exchanger as shown in above figure

3> Cross flow Heat exchanger :



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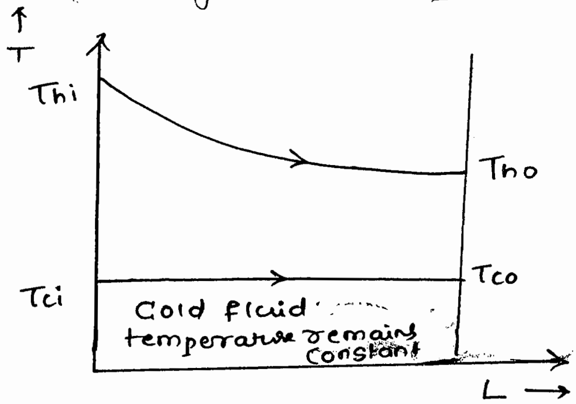
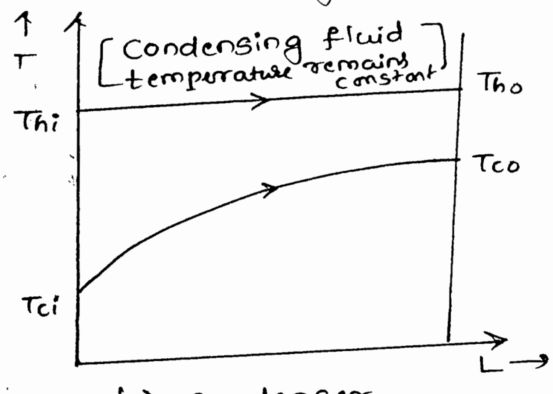
In cross flow heat exchanger the hot & cold fluids flow normal to each other

4) Evaporators & condenser :

These are special type of heat exchanger in which the temperature of one of fluid remains constant due to phase changes & temperature of Both fluid changes.



a) Evaporator



b) condenser

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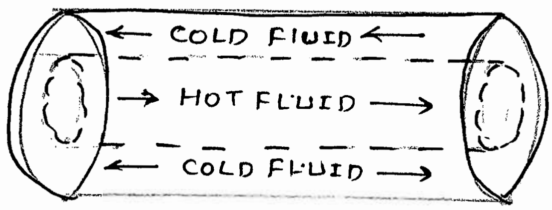
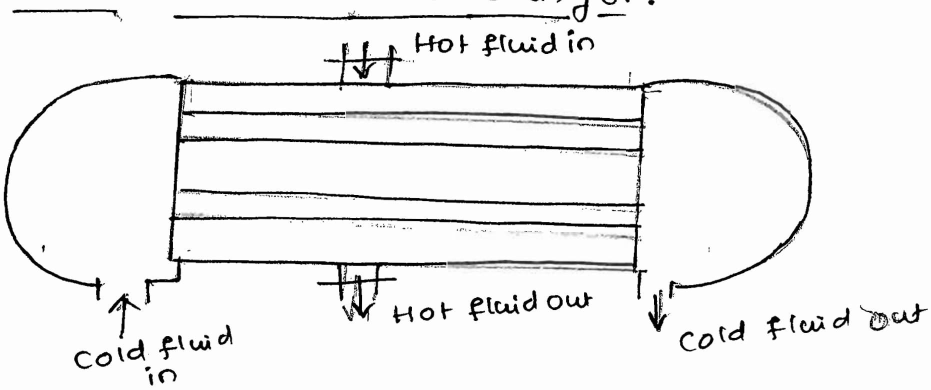
According to design & construction :

a) Concentric tube Heat Exchangers :



In this type two concentric tubes are used each carrying one of the fluids. the direction of flow may be parallel or counter flow

b) Shell & tube Heat Exchanger :



In this type one of fluid flow through bundle of tubes enclosed by shell & other fluid forced through shell & it flows over the outside surface of the tubes

c) Compact Heat Exchangers :

These type of heat exchangers have very large heat transfer area per unit volume of heat exchanger i.e more than 700 m^2

Heat transfer Analysis of Heat Exchanger

For predicting performance of heat exchanger it is neccesary total heat transfer may related with following Governing parameters.

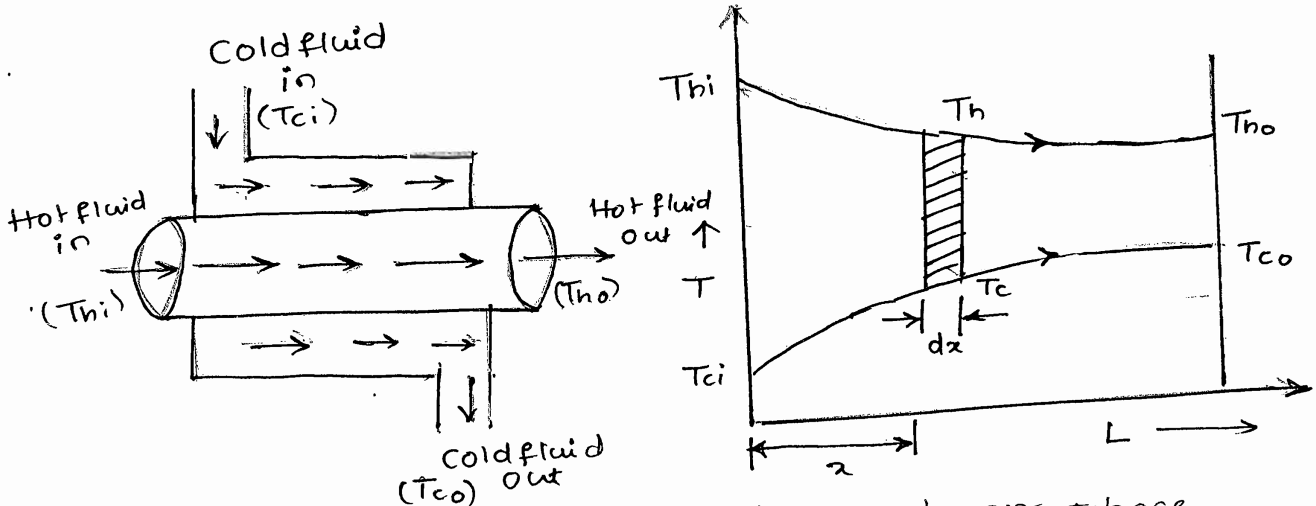
1) overall heat transfer coefficient (U)
2) Total Surface area (A)
3) Log mean temperature difference (LMTD)

Assuming that there is no heat lost to surrounding & PE & KE changes are negligible.

Assumption made in derivations of LMTD :

1) The overall heat transfer coefficient (U) is uniform throughout heat exchanger
2) The specific heat (Cp) & mass flow rates of both fluids are constant
3) The changes in PE & KE are neglected
4) The heat exchange takes place only between two fluids
5) The temperature of both fluids remains constant over given cross section.

** LMTD Equation for Parallel flow heat exchangers



Consider a parallel flow heat exchanger whose temperature distribution diagram is as shown in above figure

Let $\dot{m}_h$ = mass of hot fluid per unit time

C_{ph} = Specific heat of hot fluid

m_c = mass of cold fluid flow per unit time

C_{pc} = Specific heat of cold fluid

T_{hi} = Inlet temperature of hot fluid

T_{ho} = Outlet temperature of hot fluid

T_{ci} = Inlet temperature of cold fluid

T_{co} = Outlet temperature of Cold fluid.

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Let

$$C_h = m_h \cdot C_{ph} \quad \text{--- (1)}$$ → Heat capacity rate of hot fluid

$$C_c = m_c \cdot C_{pc} \quad \text{--- (2)}$$ → Heat capacity rate of cold fluid.

From temperature distribution diagram its clear that

$$\theta_i = (T_{hi} - T_{ci}) \quad \text{--- (3)}$$

$$\theta_o = (T_{ho} - T_{co}) \quad \text{--- (4)}$$

Consider an element of fluid at a distance (x) whose thickness is dx as shown in above figure. the temperature difference between hot & Cold fluid sides of this Strip is given by:

$$\theta = (T_h - T_c)$$

Differentiating above expression partially

$$d\theta = dT_h - dT_c \quad \text{--- (5)}$$

Let dQ be small quantity of heat transferred in elemental thickness (dx) through an elemental area (dA) then

$$dQ = -C_h \cdot dT_h = +C_c \cdot dT_c = U\,(dA)\,\theta$$

[−ve sign → Temperature decreases with increase in length (HOT FLUID)
+ve sign → Temperature increases with increase in length (COLD FLUID)]

From eqn (5) we have

$$d(\theta) = dT_h - dT_c$$

$$d(\theta) = \frac{-U \cdot dA \cdot \theta}{C_h} - \frac{U \cdot dA \cdot (\theta)}{C_c}$$

$$d(\theta) = -U \cdot (dA)\,\theta \left[\frac{1}{C_h} - \frac{1}{C_c}\right]$$

$$\frac{d\theta}{\theta} = -U \cdot dA \left[\frac{1}{C_h} - \frac{1}{C_c}\right] \quad \text{— (7)}$$

Integrating eqn (7) between limits θ_i to θ_o we ha[ve]

$$\int_{\theta_i}^{\theta_o} \frac{d\theta}{\theta} = -U \left[\frac{1}{C_h} + \frac{1}{C_c}\right] \int_0^A dA$$

$$\ln \frac{\theta_o}{\theta_i} = -U \cdot A \left[\frac{1}{C_h} + \frac{1}{C_c}\right]$$

$$\ln \frac{\theta_i}{\theta_o} = U \cdot A \left[\frac{1}{C_h} + \frac{1}{C_c}\right] \quad \text{— (8)}$$

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From principle of heat exchanger

Heat lost by hot fluid = Heat gained by cold flui[d]

$$Q = m_h \cdot C_{ph} (T_{hi} - T_{ho}) = m_c C_{pc} (T_{co} - T_{ci})$$

$$Q = C_h (T_{hi} - T_{ho}) = C_c (T_{co} - T_{ci}) \quad \text{— (9)}$$

Considering 1st & 2nd term of equation (9) we have

$$C_h = \frac{Q}{(T_{hi} - T_{ho})} \quad \text{— (10)}$$

Considering 1st & 3rd term of eqn (9) we have

$$C_c = \frac{Q}{(T_{co} - T_{ci})} \quad \text{— (11)}$$

Substitute eqn (10) & (11) in eqn (8) we have

$$\ln\left[\frac{\theta_i}{\theta_o}\right] = +UA \left[\frac{1}{\frac{Q}{(T_{hi} - T_{ho})}} + \frac{1}{\frac{Q}{(T_{co} - T_{ci})}}\right]$$

$$\ln\left[\frac{\theta_i}{\theta_o}\right] = UA \cdot \left[\frac{(T_{hi} - T_{ho})}{Q} + \frac{(T_{co} - T_{ci})}{Q}\right]$$

$$\ln\left[\frac{\theta_i}{\theta_o}\right] = \frac{UA}{Q}\left[(T_{hi}-T_{ci}) - (T_{ho}-T_{co})\right]$$ [Rearranging terms]

$$\ln\left[\frac{\theta_i}{\theta_o}\right] = \frac{UA}{Q}\left[\theta_i - \theta_o\right]$$

$$\therefore \boxed{Q = \frac{UA\left[\theta_i - \theta_o\right]}{\ln\left[\frac{\theta_i}{\theta_o}\right]}} \quad \text{---} (12)$$

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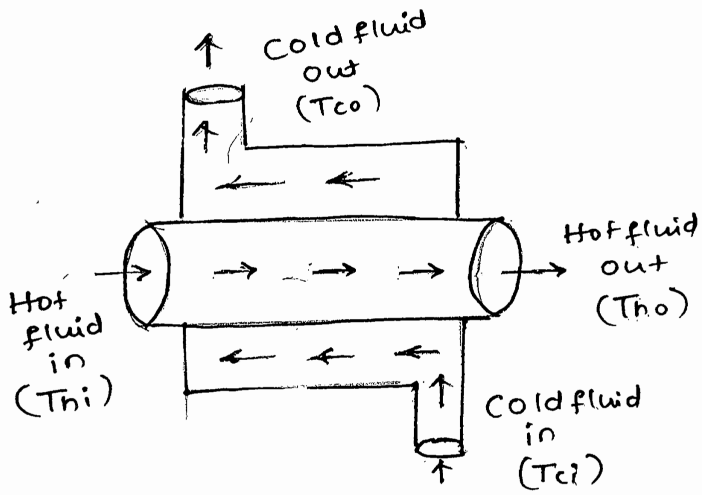
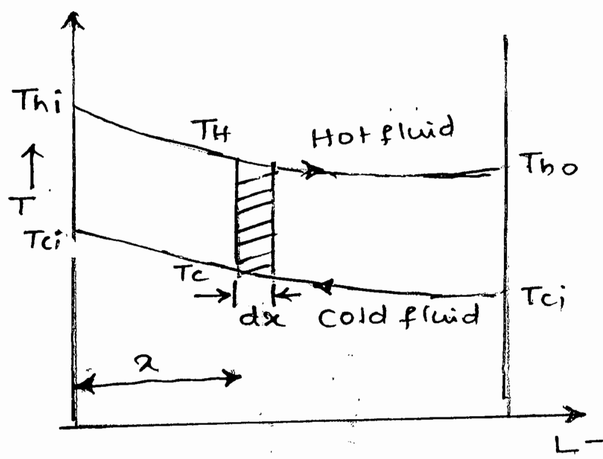
eqn (12) can also written in the form

$$\therefore \boxed{Q = UA\left[LMTD\right]} \quad \text{---} (13)$$

where $\boxed{LMTD = \frac{\theta_i - \theta_o}{\ln\frac{\theta_i}{\theta_o}}} \quad \text{---} (14)$

LMTD Equation for counter flow heat exchanger





Consider a counter flow heat exchanger whose temperature distribution diagram as shown in above

Let m_h = mass of hot fluid flow per unit time

m_c = mass of cold fluid per unit time.

C_{ph} = Specific heat of hot fluid

C_{pc} = Specific heat of cold fluid

T_{hi} = Inlet temperature of hot fluid

T_{ho} = Outlet temperature of hot fluid

T_{ci} = Inlet temperature of cold fluid.

T_{co} = Outlet temperature of cold fluid.

Let

$$C_h = m_h \cdot C_{ph} \quad \text{--- (1)}$$ → Heat capacity rate of hot fluid

$$C_c = m_c \cdot C_{pc} \quad \text{--- (2)}$$ → Heat capacity rate of cold fluid.

From temperature distribution diagram it is clear that

$$\theta_i = T_{hi} - T_{co} \quad \text{--- (3)}$$

$$\theta_o = T_{ho} - T_{ci} \quad \text{--- (4)}$$

Consider an element of fluid (dx) at a distance x as shown in figure. The temperature difference between hot & cold fluid side of strip is given by

$$\theta = T_h - T_c$$

Differentiate above expression partially

$$d\theta = dT_h - dT_c \quad \text{--- (5)}$$

Let dQ be small quantity of heat transferred in element (dx) through an elemental area (dA) then

$$dQ = -C_h \cdot d(T_h) = -C_c (dT_c) = U \cdot dA\ \theta \quad \text{--- (6)}$$

From eqn (5) we have

$$d\theta = dT_h - dT_c$$

$$d\theta = -\frac{U \cdot (dA)\ \theta}{C_h} + \frac{U \cdot (dA) \cdot \theta}{C_c}$$

$$d\theta = -U \cdot (dA)\ \theta \left[\frac{1}{C_h} - \frac{1}{C_c}\right]$$

$$\frac{d\theta}{\theta} = -U \cdot dA \left[\frac{1}{C_h} - \frac{1}{C_c}\right] \quad \text{--- (7)}$$

Integrating eqn (7) between the limits θ_i to θ_o we have

$$\int_{\theta_i}^{\theta_o} \frac{d\theta}{\theta} = -U \times \left[\frac{1}{C_h} - \frac{1}{C_c}\right] \int_0^A dA$$

$$\ln\left[\frac{\theta_o}{\theta_i}\right] = -U\left[\frac{1}{C_h} - \frac{1}{C_c}\right]\cdot A$$

$$\ln\left[\frac{\theta_i}{\theta_o}\right] = +UA\left[\frac{1}{C_h} - \frac{1}{C_c}\right] \quad \text{--- (8)}$$

From principle of heat exchanger

Heat lost by hot fluid = Heat gained by cold fluid

$$Q = m_h \cdot C_{ph}(T_{hi} - T_{ho}) = m_c C_{pc}(T_{co} - T_{ci})$$

$$Q = C_h(T_{hi} - T_{ho}) = C_c(T_{co} - T_{ci}) \quad \text{--- (9)}$$

Considering 1st & 2nd term of eqn (9) we have

$$C_h = \frac{Q}{(T_{hi} - T_{ho})} \quad \text{--- (10)}$$

Considering 1st & 3rd term of eqn (9) we have

$$C_c = \frac{Q}{(T_{co} - T_{ci})} \quad \text{--- (11)}$$

Substitute eqn (10) & (11) in eqn 8 we have

$$\ln\left[\frac{\theta_i}{\theta_o}\right] = +UA\left[\frac{1}{\frac{Q}{(T_{hi}-T_{ho})}} - \frac{1}{\frac{Q}{(T_{co}-T_{ci})}}\right]$$

$$\ln\left[\frac{\theta_i}{\theta_o}\right] = UA\left[\frac{(T_{hi}-T_{ho})}{Q} - \frac{(T_{co}-T_{ci})}{Q}\right]$$

$$\ln\left[\frac{\theta_i}{\theta_o}\right] = \frac{UA}{Q}\left[(T_{hi}-T_{ho}) - (T_{co}-T_{ci})\right]$$

$$\ln\left[\frac{\theta_i}{\theta_o}\right] = \frac{UA}{Q}\left[(T_{hi}-T_{co}) - (T_{ho}-T_{ci})\right]$$

↑ Rearranging terms

$$\ln\left[\frac{\theta_i}{\theta_o}\right] = \frac{UA}{Q}\left[\theta_i - \theta_o\right]$$

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$$Q = \frac{UA\left[\theta_i - \theta_o\right]}{\ln\left[\frac{\theta_i}{\theta_o}\right]} \quad \text{--- (12)}$$

eqn (12) can also be written as

$$Q = +UA\left[LMTD\right] \quad \text{--- (13)}$$

Where $$LMTD = \frac{\left[\theta_i - \theta_o\right]}{\ln\left[\frac{\theta_i}{\theta_o}\right]} \quad \text{--- (14)}$$

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Scaling or Fouling in a Heat Exchanger:

The surface of heat exchanger becomes more heat resistant with scaling or deposits which are formed due to impurities in the fluid, chemical reaction between fluid & wall material, rust formation etc. The effect of these deposits felt in terms of increased surface resistance affecting value of overall heat transfer coefficient.

This effect is taken in to consideration in analysis of heat exchanger by an additional thermal resistance known as fouling resistance (R_f)

Representing fouling resistance as (R_{fi}) & (R_{fo}) at inner & outer surfaces the overall heat transfer coefficient is thus given by

page no 151/165

$$\frac{1}{U_o} = \left(\frac{r_o}{r_i}\right)\frac{1}{h_i} + \left(\frac{r_o}{r_i}\right)R_{fi} + \left(\frac{r_o}{K}\right)\ln\left(\frac{r_o}{r_i}\right) + R_{fo} + \frac{1}{h_o} \quad \text{--- (1)}$$

$$\frac{1}{U_i} = \frac{1}{h_i} + R_{fi} + \left(\frac{r_i}{K}\right)\ln\left(\frac{r_o}{r_i}\right) + \left(\frac{r_o}{r_i}\right)R_{fo} + \left(\frac{r_i}{r_o}\right)\frac{1}{h_o} \quad \text{--- (2)}$$

Where U_o = overall heat transfer coefficient based on outer surface of tube

U_i = overall heat transfer coefficient based on inner surface of tube

K S INSTITUTE OF TECHNOLOGY

DEPARTMENT OF MECHANICAL ENGINEERING

YEAR / SEMESTER	**III / VI**
COURSE TITLE	**HEAT TRANSFER**
COURSE CODE	**15ME63**
ACADEMIC YEAR	**2018-19**

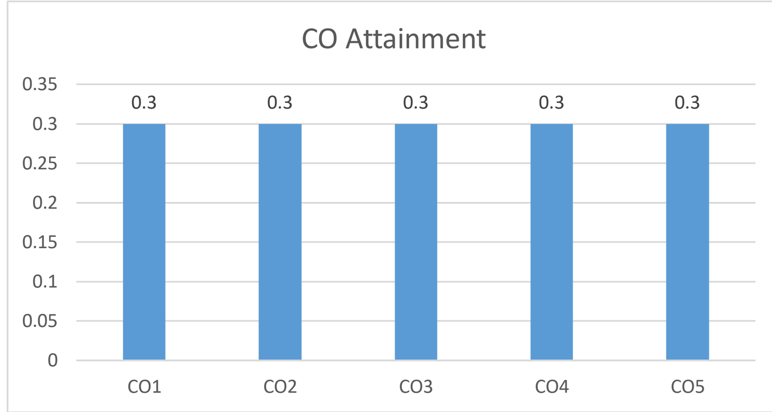
CO Attainment Level	Significance
Level 3	60% and above students should have scored >= 60% of Total marks
Level 2	55% to 59% of students should have scored >= 60% of Total marks
Level 1	50% to 54% of students should have scored >= 60% of Total marks

For Direct attainment , 50% of CIE and 50% of SEE marks are considered.
For indirect attainment, Course end survey is considered.
CO attainment is 90%of direct attainment + 10% of Indirect atttainment.
PO attainment = CO-PO mapping strength/3 * CO attainment .

Sl. No	USN	Name of the Student	15ME63																														SEE
			IA1					A1					IA2					A2					IA3					A3					
			CO1	CO2	CO3	CO4	CO5	CO1	CO2	CO3	CO4	CO5	CO1	CO2	CO3	CO4	CO5	CO1	CO2	CO3	CO4	CO5	CO1	CO2	CO3	CO4	CO5	CO1	CO2	CO3	CO4	CO5	
			20	**5**		**5**		**10**	**6**		**4**			**15**	**10**		**5**		**4**	**10**		6			10	10	10				6	14	**80**
1	1KS16ME002	ABHIJEETH.B.BHAT	15	4		5		10	6		4			10	8		4		4	10		6			0	0	0				6	14	51
2	1KS16ME004	ABHILASH.S	17	4		5		10	6		4			12	10		0		4	10		6			0	0	0				6	14	54
3	1KS16ME006	ABHISHEK PAREEK	19	5		3		10	6		4			8	7		5		4	10		6			9	10	10				6	14	30
4	1KS16ME007	ABHISHEK RAJ- Got Eligible VP	8	2		3		10	6		4			4	4		0		4	10		6			7	3	3				6	14	15
5	1KS16ME008	AMOGHA.M.KEKUDA	20	5		5		10	6		4			6	10		5		4	10		6			0	0	0				6	14	53
6	1KS16ME009	ASHOK KUMAR KARMALI	12	5		5		10	6		4			9	10		0		4	10		6			0	0	0				6	14	41
7	1KS16ME010	ASHWIN MAIYA.M	0	0		0		10	6		4			7	9		1		4	10		6			10	10	8				6	14	49
8	1KS16ME011	BHARATHKUMAR.P	13	5		5		10	6		4			10	9		0		4	10		6			6	8	7				6	14	60
9	1KS16ME012	BHARGAV JOSHI	0	0		0		10	6		4			9	7		0		4	10		6			5	5	5				6	14	49
10	1KS16ME013	BHUVAN BHARADWAJ.V.K	7	3		5		10	6		4			7	7		0		4	10		6			9	10	10				6	14	36
11	1KS16ME014	CHANDAN KUMAR.N.P	17	5		5		10	6		4			11	7		5		4	10		6			10	10	10				6	14	59
12	1KS16ME015	CHIRAG.B.P	10	5		3		10	6		4			4	7		5		4	10		6			8	9	3				6	14	40
13	1KS16ME016	DEEPAK.R.GOWDA	10	5		5		10	6		4			5	9		0		4	10		6			0	0	0				6	14	39
14	1KS16ME019	HARISH HADIMANI	17	5		5		10	6		4			12	10		0		4	10		6			0	0	0				6	14	44
15	1KS16ME021	HARSHA.S	8	3		5		10	6		4			0	0		0		4	10		6			9	4	4				6	14	45
16	1KS16ME022	HARSHAVARDHAN.N	10	5		5		10	6		4			12	10		5		4	10		6			10	10	10				6	14	52
17	1KS16ME023	HARSHITH.S	13	5		5		10	6		4			8	9		5		4	10		6			0	0	0				6	14	50
18	1KS16ME024	HEMANTH.R	5	3		4		10	6		4			6	8		0		4	10		6			8	10	5				6	14	44
19	1KS16ME025	HEMANTH KUMAR.D.L	7	3		5		10	6		4			5	8		0		4	10		6			10	9	10				6	14	43
20	1KS16ME026	HITESH.C.S	14	5		5		10	6		4			12	10		0		4	10		6			0	0	0				6	14	38
21	1KS16ME027	IMRAN KHAN	14	5		5		10	6		4			9	9		0		4	10		6			0	0	0				6	14	58
22	1KS16ME028	IRANNA CHANABASAPPA TELI	11	0		2		10	6		4			0	9		0		4	10		6			9	10	9				6	14	36
23	1KS16ME029	JAGADISH.P.SHETTI	0	0		0		10	6		4			7	10		0		4	10		6			4	10	6				6	14	28
24	1KS16ME030	JAYANTH.P	10	5		5		10	6		4			0	0		0		4	10		6			5	5	5				6	14	50
25	1KS16ME031	JAYDEEP.B	10	5		5		10	6		4			9	10		0		4	10		6			0	0	0				6	14	34
26	1KS16ME032	JUNAID KHAN	2	5		5		10	6		4			6	8		0		4	10		6			0	0	0				6	14	44
27	1KS16ME033	KANISHKA.P.SHANKAR	5	5		5		10	6		4			6	10		0		4	10		6			9	9	10				6	14	28
28	1KS16ME035	KAUSHIK.K.H	0	0		0		10	6		4			4	8		0		4	10		6			10	10	10				6	14	46
29	1KS16ME036	KIRAN PRAKASH AKOLKAR	15	5		5		10	6		4			7	7		2		4	10		6			0	0	0				6	14	52
30	1KS16ME038	M.VENKATESH KASHYAP	8	4		2		10	6		4			6	10		5		4	10		6			6	10	8				6	14	41
31	1KS16ME040	MADAN.S	10	3		5		10	6		4			6	9		5		4	10		6			10	10	10				6	14	50
32	1KS16ME044	MANOJ.R	8	5		5		10	6		4			10	5		0		4	10		6			10	0	10				6	14	31
33	1KS16ME045	MOHAMMED YASIR RIAZ	8	5		5		10	6		4			13	10		5		4	10		6			6	6	4				6	14	31
34	1KS16ME046	MOHAN KUMAR.N	11	3		5		10	6		4			0	0		0		4	10		6			4	7	8				6	14	32
35	1KS16ME047	NAGARJUN.S	0	0		0		10	6		4			5	0		0		4	10		6			10	5	10				6	14	19
36	1KS16ME048	NAGARJUN.S	12	5		5		10	6		4			3	7		0		4	10		6			5	5	9				6	14	53
37	1KS16ME049	NAGESH.T.S	12	3		5		10	6		4			3	7		5		4	10		6			10	10	10				6	14	40
38	1KS16ME052	NAVEEN DESHPANDE	0	0		0		10	6		4			9	5		0		4	10		6			10	10	10				6	14	30
39	1KS16ME053	NITHIN.N	7	0		0		10	6		4			6	5		0		4	10		6			10	10	10				6	14	31
40	1KS16ME054	P.VIGNESH	17	5		5		10	6		4			14	10		5		4	10		6			0	0	0				6	14	54
41	1KS16ME055	PAPPU KUMAR SINGH	5	8		0		10	6		4			9	10		2		4	10		6			0	0	0				6	14	36
42	1KS16ME056	PAVAN KUMAR.L	0	0		5		10	6		4			3	10		0		4	10		6			0	8	5				6	14	35
43	1KS16ME057	PAVITHRA.B	7	3		5		10	6		4			16	38				4	10		6			5	10	5				6	14	55
44	1KS16ME058	PECHU MUTHU.S	20	5		5		10	6		4			9	8		5		4	10		6			10	10	9				6	14	66
45	1KS16ME060	PRAJWAL KRISHNA	0	0		0		10	6		4			9	5		3		4	10		6			8	0	5				6	14	31
46	1KS16ME061	PRAKASH RAJU.S	0	0		0		10	6		4			5	5		0		4	10		6			10	10	10				6	14	28
47	1KS16ME062	PRAMOD.R	0	0		0		10	6		4			10	9		5		4	10		6			5	8	8				6	14	49
48	1KS16ME063	PRAMOD RAJ.K	15	3		5		10	6		4			13	10		5		4	10		6			0	0	0				6	14	57
49	1KS16ME064	PRANAV.J.ATHREY	0	0		0		10	6		4			15	10		0		4	10		6			5	8	9				6	14	43
50	1KS16ME067	RAJKUMAR.S.K	8	2		3		10	6		4			0	0		0		4	10		6			5	6	8				6	14	28
51	1KS16ME069	RAMESH PAL.P	0	0		0		10	6		4			8	4		0		4	10		6			0	4	9				6	14	A
52	1KS16ME070	RISHI.R.NAIK	5	0		5		10	6		4			2	10		0		4	10		6			5	9	5				6	14	41
53	1KS16ME073	SAGAR.N	7	5		5		10	6		4			5	9		0		4	10		6			7	4	8				6	14	39

54	1KS16ME075	SHAIK MOINUDDIN	19	5		5		10	6		4			12	9		1		4	10		6			10	10	10				6	14	43
55	1KS16ME076	SHARATH.S.YADAV	6	3		5		10	6		4			11	5		0		4	10		6			0	0	0				6	14	28
56	1KS16ME081	SHIVARAJ.N.S	8	2		5		10	6		4			7	4		0		4	10		6			0	0	0				6	14	50
57	1KS16ME082	SHIVASHANKAR.B.M	0	0		0		10	6		4			11	10		5		4	10		6			10	10	10				6	14	56
58	1KS16ME083	SIRISH GOVARDHAN	8	5		2		10	6		4			4	10		0		4	10		6			5	10	9				6	14	35
59	1KS16ME084	SOWJANYA.D	9	5		3		10	6		4			9	10		0		4	10		6			8	9	7				6	14	35
60	1KS16ME085	SREEKARA.K.B	15	4		2		10	6		4			11	10		0		4	10		6			0	0	0				6	14	45
61	1KS16ME086	SUDARSHAN.T	15	0		2		10	6		4			8	10		0		4	10		6			10	6	2				6	14	56
62	1KS16ME087	SUDHARSHAN.M.D	10	5		2		10	6		4			3	5		0		4	10		6			5	10	8				6	14	50
63	1KS16ME089	SUMESH.R	7	5		5		10	6		4			7	7		0		4	10		6			10	9	2				6	14	29
64	1KS16ME090	SUPREETH.K.R	9	3		0		10	6		4			0	0		0		4	10		6			10	7	5				6	14	44
65	1KS16ME093	VARUN.C	0	0		0		10	6		4			9	10		5		4	10		6			10	8	10				6	14	38
66	1KS16ME094	VASANTH KUMAR.S	11	5		3		10	6		4			3	5		0		4	10		6			8	10	8				6	14	52
67	1KS16ME095	VIJAYA KUMAR.M.S	15	5		5		10	6		4			10	9		0		4	10		6			0	0	0				6	14	41
68	1KS16ME096	VIJAYKUMARNAIK.T.C	9	5		2		10	6		4			7	8		0		4	10		6			6	5	9				6	14	38
69	1KS16ME097	VINAY.B.V	0	0		0		10	6		4			10	5		0		4	10		6			3	0	5				6	14	44
70	1KS16ME098	VINAY.V.P	5	0		3		10	6		4			0	5		0		4	10		6			5	9	5				6	14	28
71	1KS16ME099	VINITH.P	6	2		2		10	6		4			5	4		0		4	10		6			9	5	4				6	14	43
72	1KS16ME100	VITHAN.T.R	0	0		0		10	6		4			3	3		0		4	10		6			7	9	9				6	14	51
73	1KS17ME401	ARUNKUMAR.E	5	5		5		10	6		4			10	10		0		4	10		6			1	0	0				6	14	47
74	1KS17ME402	ARUN KUMAR.R	0	0		0		10	6		4			14	8		0		4	10		6			0	5	4				6	14	A
75	1KS17ME404	CHETHAN.C.R	10	2		2		10	6		4			5	10		0		4	10		6			0	0	0				6	14	36
76	1KS17ME405	DARSHAN.H.R	10	5		2		10	6		4			14	10		0		4	10		6			0	0	0				6	14	30
77	1KS17ME406	DEEPAK.E	0	0		0		10	6		4			10	10		0		4	10		6			10	10	10				6	14	52
78	1KS17ME407	DEVIPRASAD.M	8	3		1		10	6		4			0	0		0		4	10		6			9	5	9				6	14	32
79	1KS17ME408	GUHAN BHASKAR	8	3		0		10	6		4			5	10		0		4	10		6			8	6	2				6	14	32
80	1KS17ME409	GURUPRASAD.T.M	9	3		2		10	6		4			11	10		0		4	10		6			0	0	0				6	14	28
81	1KS17ME410	GURUSWAMY.H	10	3		0		10	6		4			0	0		0		4	10		6			9	9	10				6	14	33
82	1KS17ME411	JEEVAN ABHISHEK	11	5		3		10	6		4			13	9		0		4	10		6			0	0	0				6	14	30
83	1KS17ME412	KANTHARAJU.K.N	9	5		2		10	6		4			10	10		0		4	10		6			0	0	0				6	14	38
84	1KS17ME413	KIRAN.S	5	5		0		10	6		4			10	9		0		4	10		6			6	0	9				6	14	53
85	1KS17ME415	LOHITH.R	10	5		4		10	6		4			15	10		0		4	10		6			9	8	8				6	14	34
86	1KS17ME416	MAHADEVA RAJU.H.E	8	5		3		10	6		4			15	6		0		4	10		6			0	0	0				6	14	20
87	1KS17ME417	MAHESH.D	15	5		2		10	6		4			10	10		0		4	10		6			0	0	0				6	14	33
88	1KS17ME418	MANISH.N.D	10	5		2		10	6		4			0	0		0		4	10		6			10	10	10				6	14	32
89	1KS17ME419	MITHUN.S	10	5		0		10	6		4			0	0		0		4	10		6			10	10	10				6	14	28
90	1KS17ME420	MOHAN KUMAR.C	10	5		2		10	6		4			0	0		0		4	10		6			10	10	10				6	14	41
91	1KS17ME421	MOHAN KUMAR.K	5	3		0		10	6		4			10	9		0		4	10		6			10	10	0				6	14	32
92	1KS17ME422	NAGESH.S	7	3		0		10	6		4			2	4		0		4	10		6			4	9	8				6	14	32
93	1KS17ME423	NIKHIL GOWDA.N.S	8	3		0		10	6		4			5	7		0		4	10		6			8	8	5				6	14	45
94	1KS17ME425	PRATAP.L	0	0		0		10	6		4			5	10		0		4	10		6			5	0	10				6	14	15
95	1KS17ME426	PRATHEEK.P	4	0		0		10	6		4			5	7		0		4	10		6			5	3	10				6	14	38
96	1KS17ME430	RAKESH.B.R	0	0		0		10	6		4			5	10		0		4	10		6			10	4	6				6	14	39
97	1KS17ME431	RAKSHITH.L	0	0		0		10	6		4			4	9		0		4	10		6			10	5	10				6	14	37
98	1KS17ME432	RAVI.K.R	0	0		0		10	6		4			3	9		0		4	10		6			5	10	10				6	14	14
99	1KS17ME434	SHASHANK.Y.K	7	1		2		10	6		4			5	3		0		4	10		6			7	4	8				6	14	34
100	1KS17ME435	SHASHIKUMAR.C.R	0	0		0		10	6		4			12	10		5		4	10		6			10	9	10				6	14	45
101	1KS17ME437	SRINIVASA.B.V	0	0		0		10	6		4			4	9		0		4	10		6			10	9	4				6	14	32
102	1KS17ME439	SURABHI.N	10	2		2		10	6		4			0	0		0		4	10		6			3	5	10				6	14	28
103	1KS17ME440	SUSHMA.Y.S	15	5		4		10	6		4			8	10		0		4	10		6			0	0	0				6	14	40
104	1KS17ME441	TEJAS.P.N	0	0		0		10	6		4			10	10		0		4	10		6			9	0	5				6	14	33
105	1KS17ME442	THRIVENI.M	20	5		4		10	6		4			15	10		0		4	10		6			0	0	0				6	14	51
106	1KS17ME444	VINAY.S	10	5		4		10	6		4			3	9		0		4	10		6			7	6	0				6	14	45
60% of Maximum marks (X)			12	03	00	03	00	06	04	00	02	00	00	09	06	00	03	00	02	06	00	04	00	00	06	06	06	00	00	00	04	08	48
No. of students above X			24	68	00	53	00	106	106	00	106	00	00	45	77	00	19	00	106	106	00	106	00	00	55	54	53	00	00	00	106	106	27
Total number of students (Y)			106	106	00	106	00	106	106	00	106	00	00	106	106	00	105	00	106	106	00	106	00	00	106	106	106	00	00	00	106	106	104
CO Percentage			22.64	64.15	#DIV/0!	50.00	#DIV/0!	100.00	100.00	#DIV/0!	100.00	#DIV/0!	#DIV/0!	42.45	72.64	#DIV/0!	18.10	#DIV/0!	100.00	100.00	#DIV/0!	100.00	#DIV/0!	#DIV/0!	51.89	50.94	50.00	#DIV/0!	#DIV/0!	#DIV/0!	100.00	100.00	25.96
			CO1	CO2	CO3	CO4	CO5	CO1	CO2	CO3	CO4	CO5	CO1	CO2	CO3	CO4	CO5	CO1	CO2	CO3	CO4	CO5	CO1	CO2	CO3	CO4	CO5	CO1	CO2	CO3	CO4	CO5	SEE
LEVEL			0	3	#DIV/0!	1	#DIV/0!	3	3	#DIV/0!	3	#DIV/0!	#DIV/0!	0	3	#DIV/0!	0	#DIV/0!	3	3	#DIV/0!	3	#DIV/0!	#DIV/0!	1	1	1	#DIV/0!	#DIV/0!	#DIV/0!	3	3	0

CO Attainment							
CO	**CIE**	**SEE**	**DIRECT ATTAINMENT**	**Level**	**COURSE EXIT SURVEY**	**LEVEL**	**ATTAINMENT**
CO1	**71.23**	**25.96**	**48.60**	**0.00**	**60.00**	**3.00**	**0.3**
CO2	**65.57**	**25.96**	**45.77**	**0.00**	**60.00**	**3.00**	**0.3**
CO3	**73.58**	**25.96**	**49.77**	**0.00**	**60.00**	**3.00**	**0.3**
CO4	**69.80**	**25.96**	**47.88**	**0.00**	**60.00**	**3.00**	**0.3**
CO5	**68.81**	**25.96**	**47.39**	**0.00**	**60.00**	**3.00**	**0.3**
AVERAGE							**0.30**



	IA1	A1	IA2	A2	IA3	A3	AVG
CO1	22.64	100.00	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	71.23
CO2	64.15	100.00	42.45	100.00	#DIV/0!	#DIV/0!	65.57
CO3	#DIV/0!	#DIV/0!	72.64	100.00	51.89	#DIV/0!	73.58
CO4	50.00	100.00	#DIV/0!	#DIV/0!	50.94	100.00	69.80
CO5	#DIV/0!	#DIV/0!	18.10	100.00	50.00	100.00	68.81

						Co-Po Mapping Table							
CO'S	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PS01**	**PSO2**
CO1	3	3	2	2	1	2	1	2	1	2	_	2	3	2
CO2	3	3	2	2	1	2	1	2	1	2	_	2	3	2
CO3	3	3	2	2	1	2	1	2	1	2	_	2	3	2
CO4	3	3	2	2	1	2	1	2	1	2	_	2	3	2
CO5	3	3	2	2	1	2	1	2	1	2	_	2	3	2
AVG	3.00	3.00	2.00	2.00	1.00	2.00	1.00	2.00	1.00	2.00	_	2.00	3.00	2.00

PO ATTAINMENT TABLE																
CO'S	**CO Attainment in %**	**CO RESULT**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PS02**
CO1	0.30	N	0.30	0.30	0.20	0.20	0.10	0.20	0.10	0.20	0.10	0.20	_	0.20	0.30	0.20
CO2	0.30	N	0.30	0.30	0.20	0.20	0.10	0.20	0.10	0.20	0.10	0.20	_	0.20	0.30	0.20
CO3	0.30	N	0.30	0.30	0.20	0.20	0.10	0.20	0.10	0.20	0.10	0.20	_	0.20	0.30	0.20
CO4	0.30	N	0.30	0.30	0.20	0.20	0.10	0.20	0.10	0.20	0.10	0.20	_	0.20	0.30	0.20
CO5	0.30	N	0.30	0.30	0.20	0.20	0.10	0.20	0.10	0.20	0.10	0.20	_	0.20	0.30	0.20
Average			0.30	0.30	0.20	0.20	0.10	0.20	0.10	0.20	0.10	0.20	_	0.20	0.30	0.20