INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)
Dundigal, Hyderabad - 500 043

MECHANICAL ENGINEERING

COURSE DESCRIPTION FORM

Course Title	HEAT TRANSFER			
Course Code	**A60331**			
Regulation	**R15**			
Course Structure	Lectures	Tutorials	Practicals	Credits
	4	1	-	4
Course Coordinator	Mrs. N. Santhi Sree, Assistant Professor, Department of Mechanical Engineering.			
Team of Instructors	Mrs. N. Santhi Sree, Assistant Professor Mr. S. Srikrishnan, Assistant Professor			

I. COURSE OVERVIEW:

Heat transfer is the flow of thermal energy driven by thermal non-equilibrium, commonly measured as a heat flux, i.e. the heat flow per unit time at a control surface. This course focuses on the problems and complexities of heat transfer and emphasizes on analysis using correlations. The course assumes basic understanding of thermodynamic and fluid mechanics and exposure to differential equations and methods of solutions. Topics include modes of heat transfer and their laws, boundary conditions, conduction heat transfer – three dimensional, one dimensional steady and unsteady without heat generation, variable thermal conductivity, fin analysis, lumped heat capacity systems, free and forced convection with dimensional analysis, laminar boundary layer theory, heat exchangers, heat transfer with phase change and radiation heat transfer.

II. PREREQUISITE(S):

Level	Credits	Periods / Week	Prerequisites
UG	4	5	Thermodynamics, Fluid Mechanics, Engineering mechanics.

III. MARKS DISTRIBUTION:

Sessional Marks (25)	University End Exam Marks	Total Marks
Continuous Assessment Tests (Midterm examinations): There shall be 2 midterm examinations. Each midterm examination consists of one objective paper, one subjective paper and one assignment. The objective paper is for 10 marks and subjective paper is for 10 marks, with duration of 1 hour 20 minutes (20 minutes for objective and 60 minutes for subjective paper). Objective paper is set for 20 bits of – multiple choice questions, fill-in the blanks for 10 marks. Subjective paper contains of 4 full questions of which, the student has to answer 2 questions, each question carrying 5 marks. First midterm examination shall be conducted for 2.5 units of syllabus and second midterm examination shall be conducted for another 2.5 units. 5 marks are allocated for assignments. First assignment should be submitted before the conduct of the first mid, and the second assignment should be submitted before the conduct of the second mid. The total marks secured by the student in each	75	100

midterm examination are evaluated for 25 marks, and the average of the two midterm examinations shall be taken as the final marks secured by each candidate.		

IV. EVALUATION SCHEME:

S. No.	Component	Duration	Marks
1	I Mid Examination	80 min	20
2	I Assignment		5
		TOTAL	**25**
3	II Mid Examination	80 min	20
4	II Assignment		5
		TOTAL	**25**
	MID Examination marks to be considered as average of above 2 MID's TOTAL		
5	EXTERNAL Examination	3 hours	75
		GRAND TOTAL	**100**

V. COURSE OBJECTIVES:

I. Understand the basic modes of heat transfer and deduce its governing equations.
II. Comprehend the heat transfer coefficient and constants.
III. Visualize the emission phenomenon.
IV. Apply the heat transfer concept to heat exchangers.
V. Familiarize heat transfer data hand book.

VI. COURSE OUTCOMES:

At the end of the course the students are able to:

1. Understand basic concepts of modes of heat transfer
2. Remember the basic laws of energy involves heat transfer mechanisms
3. Understand the physical system to convert into mathematical model depending upon the mode of Heat Transfer
4. Understand the thermal response of engineering systems for application of Heat Transfer mechanism in both steady and unsteady state problems
5. Understand the concept of dimensional analysis to implement on convective heat transfer
6. Remember dimensionless numbers which are used for forced and free convection phenomena
7. Correlate convective heat transfer phenomena with dimensionless numbers
8. Understand phase change heat transfer involves boiling and condensation
9. Remember the basic laws for radiation mode of heat transfer
10. Understand the concepts of black and gray body radiation heat transfer
11. Understand the basic applications of heat exchangers and its analysis
12. Conduct experiments and analyze data involving all the modes of heat transfer
13. Remember the concepts to work out real time problems in industry which involves the concepts of Heat Transfer mechanisms

VII. HOW COURSE OUTCOMES ARE ASSESSED:

Program Outcomes		Level	Proficiency assessed by
PO1	**Engineering knowledge**: Capability to apply the knowledge of Mathematics, Science and Engineering in the field of Mechanical Engineering.	S	Assignments
PO2	**Problem analysis**: An ability to analyze complex engineering problems to arrive at relevant conclusions using knowledge of Mathematics, Science and Engineering.	H	Assignments Mid-term,

PO3	**Design/development of solutions**: Competence to design a system, compo nent or process to meet societal needs within realistic constraints.	H	Industrial Interaction
PO4	**Conduct investigations of complex problems**: To design and conduct research oriented experiments as well as to analyze and implement data using research methodologies.	H	Mid-term
PO5	**Modern tool usage**: An ability to formulate, solve complex engineering problems using modern engineering and Information Technology tools.	H	Guest Lectures
PO6	**The engineer and society**: To utilize the Engineering practices, Techniqu es, skills to meet needs of the health, safety, legal, cultural and societal issues.	N	-
PO7	**Environment and sustainability**: To understand impact of Engineering solutions in the societal context and demonstrate the knowledge for sustainable development.	N	-
PO8	**Ethics**: An understanding and Implementation of professional and Ethical responsibilities.	N	-
PO9	**Individual and teamwork**: To function as an effective individual and as a member or leader in Multi-disciplinary environment and adopt in diverse teams.	N	-
PO10	**Communication**: An ability to assimilate, comprehends, communicate, give and receive instructions to present effectively with engineering community and society.	N	-
PO11	**Project management and finance**: An ability to provide leadership in ma naging complex engineering projects at Multidisciplinary environment and to become a professional engineer.	N	-
PO12	**Life-long learning**: Recognition of the need and an ability to engage in life-long learning to keep abreast with technological changes.	H	Guest Lectures

VIII. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

	Program Specific Outcomes	Level	Proficiency assessed by
PSO1	**Professional Skills:** To produce engineering professional capable of synt hesizing and analyzing mechanical systems including allied engineering streams.	H	Industrial Interaction
PSO2	**Design/Analysis:** An ability to adopt and integrate current technologies in the design and manufacturing domain to enhance the employability.	H	Guest Lectures
PSO3	**Successful Career and Entrepreneurship:** To build the nation, by imparting technological inputs and managerial skills to become Technocrat.	N	-

IX. SYLLABUS:

UNIT – I

INTRODUCTION: Modes and mechanisms of heat transfer, Basic laws of heat transfer, Applications of heat transfer. Conduction heat transfer: Fourier rate equation- General three dimensional heat conduction equations in Cartesian, Cylindrical and Spherical coordinates **Simplification and forms of the field equation-** Steady and unsteady and periodic heat transfer-Initial and boundary conditions.

UNIT-II

One dimensional steady state conduction heat transfer - Homogeneous slabs, hollow cylinders and spheres, Overall heat transfer coefficient, Electrical analogy, Critical radius of insulation. Variable thermal conductivity and Systems with internal heat generation. Extended surfaces (Fins) Long, Short and insulated tips.

ONE DIMENSIONAL TRANSIENT HEAT CONDUCTION: Systems with negligible internal resistance, Significance of Biot and Fourier umbers, Chart solutions of transient conduction systems.

UNIT-III

CONVECTIVE HEAT TRANSFER: Classification of systems based on causation of flow, condition of flow, configuration of flow and medium of flow-Dimensional analysis as a tool for experimental investigation-Buckingham Pi Theorem and method, application for developing semi-empirical non-dimensional correlation for convection heat transfer- significance of non dimension numbers.

FORCED CONVECTION: **External Flows**: Flat plates and horizontal plates.
FREE CONVECTION: Development of Hydrodynamic and thermal boundary layer along a vertical plate - Use of empirical relations for Vertical plates and pipes

UNIT-IV

HEAT TRANSFER WITH PHASE CHANGE-BOILING: Pool boiling- regimes Calculations on Nucleate boiling, Critical heat flux, Film boiling.

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

RADIATION HEAT TRANSFER:
Emission characteristics, Laws of black-body radiation, Irradiation, Total and Monochromatic quantities, Laws of Planck, Wien, Kirchhoff, Lambert, Stefan and Boltzmann, Heat exchange between two black bodies, concepts of shape factor, Emissivity, heat exchange between grey bodies, radiation shields, and electrical analogy for radiation networks

UNIT-V

HEAT EXCHANGERS:
Classification of heat exchangers, overall heat transfer Coefficient and fouling factor, Concepts of LMTD and NTU methods, Problems using LMTD and NTU Methods

TEXT BOOKS:

T1. Yunus A. Cengel (2012), Heat Transfer a Practical Approach, 4th edition, Tata McGraw hill education (P) Ltd, New Delhi, India.
T2. R. C. Sachdeva (2012), Fundamentals of Engineering, Heat and Man Transfer, 3rd edition, New Age, New Delhi, India.
T3. Heat Transfer – P .K .Nag/TMH

REFERENCE BOOKS:

R1. Holman (2012), Heat Transfer (SI Units), 10thedition, Tata McGraw hill education (P) Ltd, New Delhi, India.
R2. P. S. Ghoshdastidar (2012), Heat Transfer, 2nd edition, Oxford University Press, New Delhi, India.
R3. Incropera, Dewitt (2012), Fundamentals of Heat Transfer, 6th edition, John Wiley,
R4. Heat and Mass Transfer by R.K.Rajput
R5. Heat and Mass Transfer – D.S .Kumar /S.K. Kataria & sons
R6. Heat and mass transfer –OZISIK

X. COURSE PLAN:

The course plan is meant as a guideline. There may probably be changes.

Lecture No.	Course Learning Outcomes	Topics to be covered	Reference
1-2	Describe basic modes of heat transfer with laws	UNIT - I INTRODUCTION Modes and mechanisms of heat transfer, Basic laws of heat transfer	T1 1-1
3	Discuss the applications of heat transfer.	Applications of heat transfer	R5
4-6	Illustrate General three dimensional heat conduction equations in different coordinates	CONDUCTION HEAT TRANSFER FOURIERS RATE : Fourier Equation , GENERAL heat conduction equations in Cartesian Cylindrical and Spherical coordinates.	T1 2-2
7	Evaluate heat transfer coefficient in all three modes and heat transfer rates	Tutorials.	R5
8	Summarize the Fourier's equation into simplified form	Simplification and forms of the field equation , Steady state and Transient heat transfer, Initial and boundary conditions	T1 -5
9-10	Derive steady state conduction in 1D	UNIT II: One dimensional steady state heat conduction heat transfer Homogeneous slabs, hollow cylinders and spheres,.	T1-5
11	Explain the concept of overall heat transfer coefficient	Overall heat transfer coefficient, Electrical analogy,	T1-3.2
12	Discuss Critical radius of insulation	Critical radius of insulation.	T1 3.5
13-14	Solve the heat transfer rate in various systems. Illustrate systems with Systems with variable thermal conductivity and Systems with internal heat generation	One dimensional steady state heat conduction heat transfer: systems with variable thermal conductivity and Systems with internal heat generation.	T1 5.3
15-16	Demonstrate the concept of Extended surfaces(fins)	Extended surfaces (Fins) , Long, Short and insulated tips.	T1 3.6
17-18	Solve the heat transfer rate value in different fins.	Tutorials.	R5T3
19	Problems on fins.	Problems.	T2
20-21	Discuss various systems with transient heat conduction and Explain the concept of lumped heat capacity.	ONE DIMENSIONAL TRANSIENT CONDUCTION HEATTRANSFER Systems with negligible internal resistance, of different geometries.	T1 4.1
22	Define biot number and Fourier's number	Significance of Biot and Fourier umbers,	T1 4.2
23-25	Solving Systems with negligible internal resistance using Chart solutions	Chart solutions of transient conduction systems.	T1 4.3
26	Classify systems with fluid flow	UNIT III CONVECTIVE HEAT TRANSFER Classification of systems based on causation flow ,condition of flow, configuration of flow and medium flow	R6 T1 6.1
27-29	. Analyze convection heat transfer with Buckingham's pi theorem and	Dimensional analysis as a tool for experimental investigation-Buckingham pi	T1 8.2

	analyze Re, NU, Pr, Gr etc dimensionless numbers	theorem Dimensional analysis-Application for developing non-dimensional correlation for convective heat transfer.	
30-32	explain all the three equations for convective heat transfer	Concepts of Continuity, Momentum and Energy Equations.	T1 8.2
33-34	Discuss the analysis of boundary layer theory for external flow. solve the systems with Forced convection external flow	FORCED CONVECTION External Flows Concepts of hydrodynamic and thermal boundary layer and use of empirical correlations for Flat plates and Cylinders	T1 7.1,7.2
35-38	solve the systems with Forced convection internal flow	Problems	R6, T1 7.1,7.2
39-40	Analyse the concept of heat transfer mechanism in free convection	FREE CONVECTION: Development of Hydrodynamic and thermal boundary layer along a vertical plate ,	T 1 9.1,9.2,9.3
40-42	Solve the systems with free convection heat transfer mechanisms	Use of empirical relations for Vertical plates and pipes.	T1 9.4
42-43	Discuss heat transfer with phase change phenomenon with different regimes of boiling	UNIT IV BOILING AND CONDENSATION: Regimes of Pool boiling and Flow boiling, Critical heat flux, Calculations on Nucleate Boiling	T1 10.1,10.2
44	Determination of critical heat flux and heat transfer rate in different regimes	critical heat flux and film boiling	T1 10.3 R1
45	Classify different types of condensation.	condensation, Film wise and drop wise condensation, Nusselt’s theory of condensation on a vertical plate	R4 T1 10.4
46-47	Determine heat transfer in condensation phenomena using Nusselt’s theory.	Film condensation on vertical and horizontal cylinders using empirical correlations	R4 T1 10.5,10.6
48	Emphasize the concept of Radiation	RADIATION Emission characteristics	T1 11.2,11.3
49-50	State the laws of black body radiation	black-body radiation, Irradiation ,Total and monochromatic quantities , Laws of Planck, Wien, Kirchhoff, Lambert, Stefan and Boltzmann	T1 11.4
51-52	Discuss heat exchange between grey bodies	Heat exchange between grey bodies.	T1 12.2
53-54	Derive shape factor for different cross sections	concepts of shape factor,	T1 12.3
55-56	Explain Radiation shields	Radiation shields, electrical analogy for radiation networks.	T1 12.5
57-58	Classify heat exchangers depends on different considerations	UNIT V HEAT EXCHANGERS Classification of heat exchangers	T1 13.1,13.2
59-61	Concept of overall heat transfer coefficient with effect of fouling	overall heat transfer Coefficient and fouling factor	T1 13.3
62-63	Determination of LMTD and NTU for different heat exchangers	Concepts of LMTD and NTU methods	T1-13.4,13.5
64-65	Solve Heat transfer rate in Heat Exchangers,	Problems using LMTD and NTU methods..	T13.6,R5 R6

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

Course Objectives	Program Outcomes												Program Specific Outcomes		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
I	S		H										S		
II					S									H	
III		H		S										H	
IV			H	S									S		
V	S				H								S		

S =Supportive **H=Highly Related**

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

Course Outcomes	Program Outcomes												Program Specific Outcomes		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
1	S	S	S		H								H		
2		S	H		S							H		H	
3			S										S		
4		H		S										H	
5			H		S							S	S		
6	S											H			
7		H			H								S		
8		S	H		S							H		H	
9														H	
10		H		S									S	H	
11			H		S							S	S		
12	S											H			
13		H												H	

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Prepared By: Mrs. N. Santhi Sree, Assistant Professor
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