INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad -500 043

AERONAUTICALENGINEERING

COURSE DESCRIPTOR

Course Title	**HEAT TRANSFER**				
Course Code	AAE515				
Programme	B.Tech				
Semester	VI	AE			
Course Type	Elective				
Regulation	IARE - R16				
Course Structure	**Theory**			**Practical**	
	Lectures	**Tutorials**	**Credits**	**Laboratory**	**Credits**
	3	1	4	-	-
Chief Coordinator	Dr. P Srinivasa Rao, Professor				
Course Faculty	Dr. Ch Sandeep, Associate Professor Dr. Ch. Apparao, Associate Professor				

I. COURSE OVERVIEW:

Heat transfer is an important engineering discipline strongly related to thermodynamics and fluid dynamics.This course is supposed to provide the fundamental concepts of heat transfer with an emphasis to aerospace applications. First,modes of heat transfer are going to be reviewed. Then, the basic principles of this thermal design of spacecraft would be introduced. Moreover, the analysis techniques and hardware used for the thermal control over spacecraft will also be introduced. The thermally challenging problem of re-entry and high-speed atmospheric flight will additionally be introduced with examples.

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. COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
UG	AME003	III	Thermodynamics	4
UG	AAE003	III	Mechanics of Fluids	4

III. MARKSDISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
Heat Transfer	70 Marks	30 Marks	100

IV. DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✘	Chalk & Talk	✔	Quiz	✔	Assignments	✘	MOOCs
✔	LCD / PPT	✔	Seminars	✘	Mini Project	✔	Videos
✘	Open Ended Experiments						

V. EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into fiveunits and each unit carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each unit. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.

The emphasis on the questions is broadly based on the following criteria:

50 %	To test the objectiveness of the concept.
50 %	To test the analytical skill of the concept OR to test the application skill of the concept.

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks (Table 1), with 25 marks for Continuous Internal Examination (CIE), 05 marks for Quiz/ Alternative Assessment Tool (AAT).

Table 1: Assessment pattern for CIA

Component	**Theory**		**Total Marks**
Type of Assessment	CIE Exam	Quiz / AAT	
CIA Marks	25	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 16^{th} week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration consisting of two parts. Part–A shall have five compulsory questions of one mark each. In part B, four out of five questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz / Alternative Assessment Tool (AAT):

Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are be answered by choosing the correct answer from a given set of choices (commonly four). Marks shall be awarded considering the average of two quizzes for every course. The AAT may include seminars, assignments, term paper, open ended experiments, five minutes video and MOOCs.

VI. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes (POs)		Strength	Proficiency assessed by
PO 1	**Engineering knowledge**: Capability to apply the knowledge of mathematics, science and engineering in the field of mechanical engineering.	3	Presentation on real-world problems
PO 2	**Problem analysis**: An ability to analyze complex engineering problems to arrive at relevant conclusion using knowledge of mathematics, science and engineering.	2	Seminar
PO 4	**Conduct investigations of complex problems**: To design and conduct research-oriented experiments as well as to analyze and implement data using research methodologies.	1	Videos

3 = High; 2 = Medium; 1 = Low

VII. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes (PSOs)		Strength	Proficiency assessed by
PSO 1	**Professional Skills:** To produce engineering professional capable of synthesizing and analyzing mechanical systems including allied engineering streams.	1	Lecture, Assignments and Seminars
PSO 2	**Software Engineering Practices:** An ability to adopt and integrate current technologies in the design and manufacturing domain to enhance the employability.	-	-
PSO3	**Successful Career and Entrepreneurship:** To build the nation, by imparting technological inputs and managerial skills to become Technocrats.	-	-

3 = High; 2 = Medium; 1 = Low

VIII. COURSE OBJECTIVES (COs):

The course should enable the students to:	
I	Understand the basic modes of heat transfer like conduction, convection and radiation with and without phase change in solid liquids and gases.
II	Design and analyze thermal fluidic components in engineering systems to energy mechanisms (in the form of heat transfer) for steady and unsteady state.
III	Conduct experiments in laboratories and analyze the results with theoretical ones to evolve research-oriented projects in the field of heat transfer as well as propulsion.
IV	Apply the concepts of heat transfer with convective mode in internal and external flows involved in engineering components and work in real time problems in Industry.

IX. COURSE OUTCOMES(COs):

COs	Course Outcome	CLOs	Course Learning Outcome
CO 1	Describe the basic concept of the mechanism of heat transfer and understand the law of energy exchange in heat transfer mechanisms. (Problem solving)	CLO 1	Understand basic concepts of heat transfer modes, Fourier Law and First law of thermodynamics.
		CLO 2	Remember the basic laws of energy involved in the heat transfer mechanisms.
		CLO 3	Understand the physical system to convert into mathematical model depending upon the mode of Heat Transfer.
		CLO 4	Understand the thermal response of engineering systems for application of Heat Transfer mechanism in both steady and unsteady state problems.
CO 2	Derive and formulate the mathematical models for steady state heat transfer phenomenon and comprehend the applicability to different surfaces and geometries. (Problem solving)	CLO 5	Understand heat transfer process and systems by applying conservation of mass and energy into a system.
		CLO 6	Understand the steady state condition and mathematically correlate different forms of heat transfer
		CLO 7	Analyze finned surfaces, and assess how fins can enhance heat transfer
		CLO 8	Remember dimensionless numbers which are used for forced and free convection phenomena.
CO 3	Understand the concept heat convection and its forms like free and forced convection. (Problem solving)	CLO 09	Understand the applications of Buckingham Pi Theorem in deriving various non dimensional numbers and their applications in heat transfer
		CLO 10	Remember and use the methodology presented in tutorial to solve a convective heat transfer problems
		CLO 11	Understand the various forms of free and forced convection and the application of the same in day to day problems
		CLO 12	Calculate local and global convective heat fluxes using Nusselt's Theory.
CO 4	Explore the concept of Boundary layer and derivation of empirical relations; also understand the concept of condensation and boiling.	CLO 13	Understand the method to evolve hydrodynamic and thermal boundary layers applied mathematically to vertical plates and Tubes
		CLO 14	Understand the physical mechanisms of phase change involving pool, nucleate and film boiling processes
		CLO 15	Understand Nusselt's theory of condensation for the application in film and drop wise condensation
		CLO 16	Correlate the empirical relations in terms of vertical and horizontal cylinders during film condensation
CO 5	Understand the concept of Radiation heat transfer. Introduction to the methods of solving real time problems	CLO 17	Understand the concepts of black and gray body radiation heat transfer.
		CLO 18	Understand the concept of shape factor and evolve a mechanism for conducive radiation shields
		CLO 19	Understand the various classifications of heat exchangers based on arrangement and correlate the effects of fouling
		CLO 20	Understand the LMTD and NTU methods and apply the same for solving real time problems in heat exchangers

X. COURSE LEARNING OUTCOMES (CLOs):

CLO Code	CLO's	At the end of the course, the student will have the ability to:	PO's Mapped	Strength of Mapping
AAE016.01	CLO 1	Understand basic concepts of heat transfer modes, Fourier Law and First law of thermodynamics.	PO 1	3
AAE016.02	CLO 2	Remember the basic laws of energy involved in the heat transfer mechanisms.	PO 1	3
AAE016.03	CLO 3	Understand the physical system to convert into mathematical model depending upon the mode of Heat Transfer.	PO 1	3
AAE016.04	CLO 4	Understand the thermal response of engineering systems for application of Heat Transfer mechanism in both steady and unsteady state problems.	PO 1	3
AAE016.05	CLO 5	Understand heat transfer process and systems by applying conservation of mass and energy into a system.	PO 1	3
AAE016.06	CLO 6	Understand the steady state condition and mathematically correlate different forms of heat transfer	PO 1	3
AAE016.07	CLO 7	Analyse finned surfaces, and assess how fins can enhance heat transfer	PO 2	2
AAE016.08	CLO 8	Remember dimensionless numbers which are used for forced and free convection phenomena.	PO 2	2
AAE016.09	CLO 9	Understand the applications of Buckingham Pi Theorem in deriving various non dimensional numbers and their applications in heat transfer	PO 4	1
AAE016.10	CLO 10	Remember and use the methodology presented in tutorial to solve a convective heat transfer problems	PO 2	2
AAE016.11	CLO 11	Understand the various forms of free and forced convection and the application of the same in day to day problems	PO 1	3
AAE016.12	CLO 12	Calculate local and global convective heat fluxes using Nusselt's Theory.	PO4	1
AAE013.13	CLO 13	Understand the method to evolve hydrodynamic and thermal boundary layers applied mathematically to vertical plates and Tubes	PO 4	1
AAE016.14	CLO 14	Understand the physical mechanisms of phase change involving pool, nucleate and film boiling processes	PO 2	2
AAE016.15	CLO 15	Understand Nusselt's theory of condensation for the application in film and drop wise condensation	PO 2	2
AAE016.16	CLO 16	Correlate the empirical relations in terms of vertical and horizontal cylinders during film condensation	PO 4	1
AAE016.17	CLO 17	Understand the concepts of black and gray body radiation heat transfer.	PO 2	2
AAE016.18	CLO 18	Understand the concept of shape factor and evolve a mechanism for conducive radiation shields	PO 2	2
AAE016.19	CLO 19	Understand the various classifications of heat exchangers based on arrangement and correlate the effects of fouling	PO 2	2
AAE016.20	CLO 20	Understand the LMTD and NTU methods and apply the same for solving real time problems in heat exchangers	PO 1	3

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XI. MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES

Course Outcomes (COs)	Program Outcomes (POs)			Program Specific Outcomes (PSOs)
	PO 1	PO 2	PO 3	PSO 1
CO 1	1	2		2
CO 2	1	2		2
CO 3	1	2	1	
CO 4	1	2	1	
CO 5		2	1	2

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

Course Learning Outcomes (CLOs)	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CLO 1	3												1		
CLO 2	3												1		
CLO 3	3												1		
CLO 4	3														
CLO 5	3														
CLO 6	3														
CLO 7		2											1		
CLO 8		2													
CLO 9				1											
CLO 10		2											1		
CLO 11	3														
CLO 12				1											
CLO 13				1											
CLO 14		2											1		
CLO 15		2											1		
CLO 16				1											
CLO 17		2													
CLO 18		2											1		
CLO 19		2											1		
CLO 20	3												1		

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XIII. ASSESSMENT METHODOLOGIES–DIRECT

CIE Exams	PO 1,PO2, PO4	SEE Exams	PO 1, PO2, PO4	Assignments	PO1	Seminars	PO 1
Laboratory Practices	-	Student Viva	-	Mini Project	-	Certification	-
Videos	PO 4						

XIV. ASSESSMENT METHODOLOGIES–INDIRECT

✔	Early Semester Feedback	✔	End Semester OBE Feedback
✘	Assessment of Mini Projects by Experts		

XV. SYLLABUS

UNIT-I	**BASIC CONCEPTS**
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 AND TRANSIENT CONDUCTION HEAT TRANSFER**
Homogeneous slabs, hollow cylinders and spheres, Overall heat transfer coefficient, Electrical analogy, and 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, concepts of continuity, momentum and energy equations. Forced convection: external flows: Concepts of hydrodynamic and thermal boundary layer and use of empirical correlations for convective heat transfer, flat plates and cylinders; Internal flows, Concepts about Hydrodynamic and thermal entry lengths, division of internal flows based on this, use of empirical correlations for horizontal pipe flow and annulus flow; free convection: Development of hydrodynamic and thermal boundary layer along a vertical plate, use of empirical relations for vertical plates and pipes.	
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, 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:
1. Yunus A. Cengel, "Heat Transfer A Practical Approach", Tata McGraw hill Education (P) Ltd, New Delhi, India. 4th Edition, 2012. 2. R. C. Sachdeva, "Fundamentals of Engineering, Heat and Mass Transfer", New Age, New Delhi, India, 3rd Edition, 2012.
Reference Books:
1. Holman, —Heat Transfer‖, Tata McGraw-Hill education, 10th Edition, 2011. 2. P. S. Ghoshdastidar, —Heat Transfer‖, Oxford University Press, 2nd Edition, 2012. 3. D. S. Kumar, —Heat and Mass Transfer‖, S.K. Kataria& sons, 9th Edition 2015.

XVI. COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

Lecture No	Topics to be covered	Course Learning Outcomes (CLOs)	Reference
1-2	Modes and mechanisms of heat transfer, Basic laws of heat transfer	CLO 1	T1 1-1
3	Applications of heat transfer	CLO 2	R5
4-6	Fourier Equation, General heat conduction equations in Cartesian, Cylindrical and Spherical coordinates.	CLO 1	T1 2-2
7-8	Simplification and forms of the field equation, steady and unsteady and periodic heat transfer.	CLO 2	R5
9-10	Transient heat transfer, Initial and boundary conditions	CLO3	T1 -5
11	One dimensional steady state heat conduction heat transfers Homogeneous slabs, hollow cylinders and spheres.	CLO 4	T1-5
12-13	Overall heat transfer coefficient, Electrical analogy,	CLO 5	T1-3.2
14	One dimensional steady state heat conduction heat transfer: systems with variable thermal conductivity and Systems with internal heat generation.	CLO 6	T1 3.5
15-17	Extended surfaces (Fins), Long, Short and insulated tips.	CLO 7	T1 5.3
18-20	Problems on Long, Short and insulated tips Fins	CLO 7	R5,T3
21-22	Systems with negligible internal resistance, of different geometries.	CLO 6	T2
23	Significance of Biot and Fourier umbers,	CLO6	T1 4.1
24	Chart solutions of transient conduction systems.	CLO 6	T1 4.2
25-26	Classification of systems based on causation flow ,condition of flow, configuration of flow and medium flow	CLO 10	T1 4.3
27 -28	Dimensional analysis as a tool for experimental investigation-Buckingham pi theorem Dimensional analysis-Application for developing non-dimensional correlation for convective heat transfer.	CLO 8	R6 T1 6.1
29-30	Concepts of Continuity, Momentum and Energy Equations.	CLO 9	T1 8.2
31-32	External Flows Concepts of hydrodynamic and thermal boundary layer and use of empirical correlations for Flat plates.	CLO 11	T1 8.2

Lecture No	Topics to be covered	Course Learning Outcomes (CLOs)	Reference
33	Problems on Forced Convection	CLO 10	T1 7.1,7.2
34	Development of Hydrodynamic and thermal boundary layer along a vertical	CLO 11	R6, T1 7.1,7.2
35	Use of empirical relations for Vertical plates and pipes.	CLO 12	T 1 9.1,9.2,9.3
36	Regimes of Pool boiling and Flow boiling, Critical heat flux, Calculations on Nucleate Boiling	CLO 13	T1 9.4
37	Critical heat flux and film boiling	CLO 14	T1 10.1,10.2
38	Condensation, Film wise and drop wise condensation, Nusselt‟s theory of condensation on a vertical plate.	CLO 15	T1 10.3 R1
39-40	Film condensation on vertical and horizontal cylinders using empirical correlations	CLO 16	R4 T1 10.4
41	Emission characteristics	CLO 17	R4 T1 10.5,10.6
42	Black-body radiation, Irradiation,Total and monochromatic quantities, Laws of Planck, Wien, Kirchhoff, Lambert, Stefan and Boltzmann.	CLO 17	T1 11.2,11.3
43	Heat exchange between grey bodies.	CLO 16	T1 11.4
44	concepts of shape factor,	CLO 16	T1 12.2
45	Comparison of thermal and non -thermal processes	CLO 17	T1 12.3
46	Radiation shields, electrical analogy for radiation networks.	CLO 17	T1 12.5
47-48	Classification of heat exchangers	CLO 18	T1 13.1,13.2
49-50	overall heat transfer Coefficient and fouling factor	CLO 19	T1 13.3
51-53	Concepts of LMTD and NTU methods	CLO 20	T1- 13.4,13.5
54-56	Problems using LMTD and NTU methods	CLO 20	T13.6, R5 R6

XVII. GAPS IN THE SYLLABUS - TO MEET INDUSTRY / PROFESSION REQUIREMENTS:

S No	Description	Proposed actions	Relevance with POs	Relevance with PSOs
1	To understand the industrial and practical applications	Guest Lecture / Semiar	PO1, PO2, PO4	PSO2
2	Encourage students to solve real time applications and prepare towards competitive examinations.	NPTEL	PO 2	PSO 1

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