Course title: Heat transfer			
Course code: ENR 189	**No. of credits:** 4	**L-T-P:** 48-12-0	**Learning hours:** 60
Pre-requisite course code and title (if any): NA			
Department: Department of Energy and Environment			
Course coordinator: Dr. Som Mondal	**Course instructor(s):** Prof. S. C. Mullick		
Contact details: som.mondal@terisas.ac.in			
Course type: Core	**Course offered in:** Semester 1		

Course description

The course is designed to familiarize the students with the basic principles of heat transfer mechanisms and applications. Students will learn in detail about the concepts of conduction, forced convection, natural convection and radiation, how their combinations contribute in any heat transfer process, how a heat transfer process can be made more efficient and how to reduce heat losses. The students would also learn about types of heat exchangers, their analysis, selection, sizing. The course also covers basics of condensation on different surfaces and different boiling regimes in pool and flow boiling.

Course objectives

- To impart knowledge of conduction, convection and radiation, their fundamental equations and correlations
- To apply the principles of heat transfer into engineering applications such as heat exchanger, heat pipe, insulation wall etc.
- To develop understanding on boiling and condensation process

Course contents

Module	Topic	L	T	P
1	**Fundamentals of Heat Transfer** Relevance and application of heat transfer in renewable energy technologies Introduction to different heat transfer mechanisms: conduction, convection and radiation	2	0	0
2	**Conduction** Steady state heat conduction in uniform solids and composite systems of rectangular, cylindrical and spherical geometries, electrical analogy, thermal contact resistance Critical thickness of insulation Heat transfer from extended surfaces Transient heat conduction, lumped system analysis, time constant	10	2	0
3	**Convection** Physical mechanisms of convection Thermal boundary layer, external and internal forced convection under laminar and turbulent flow conditions Laminar and turbulent natural convection over surfaces, natural convection inside enclosures Estimation of heat transfer coefficients in different geometry and fluid medium	16	4	0
4	**Heat Exchangers**			

	Different types of heat exchangers: plate heat exchanger, shell-and-tube heat exchangers: parallel flow and counter-flow, overall heat transfer coefficient, fouling factors Analysis of heat exchangers: logarithmic mean temperature difference (LMTD) method, effectiveness-NTU method Selection and sizing of heat exchangers	8	2	0
5	**Radiation** Thermal radiation, emission characteristics of black and grey surface Emissivity and absorptivity, Reflectivity and transmissivity, Planck's law, Stefan-Boltzmann Law, Directional intensity of radiation, Kirchhoff's Law Radiative heat transfer between surfaces, Shape factor: reciprocity relation, summation rule, superposition rule and symmetry rule Radiative heat transfer within an enclosure, radiation shield	6	2	0
6	**Boiling and Condensation** Film-wise and drop-wise condensation, estimation of heat transfer coefficients for condensation on surfaces, condensation on tube and on tube banks Pool boiling curve, nucleate and film boiling, flow boiling, estimation of heat transfer coefficients in nucleate boiling Principle and construction of heat pipe	6	2	0
		48	**12**	**0**

Evaluation criteria

- Assignments: 20% (During Module 2-5)
- Written Test 1: 15% (after Module 2)
- Written Test 2: 15% (after Module 4)
- Written Test 3: 50% (after Module 6)

Learning outcomes

After studying this course students will be able to:

- Develop fundamental understanding of different heat transfer processes and relate them to practical problems in renewable energy technologies (Assignments and Test 1)
- Model heat transfer problems and solve it (Test 1,2,3)
- Develop the skill to analyse heat exchangers, their sizing and selection (Test 2,3)
- Understand heat exchange process through boiling and condensation (Test 3)

Pedagogical approach:

A combination of class-room interactions, tutorials, assignments and group projects.

Reading materials

Text Books

S. P. Sukhatme, "A Textbook on Heat Transfer", Fourth Edition (University Press India Ltd., 2005)
YA Cengel. "Heat and Mass Transfer: A practical approach", Third Edition (Tata McGraw Hill, 2005)

Reference Books

JP Holman, “Heat Transfer”, Ninth Edition (Tata McGraw-Hill, 2007) PK Nag, “Heat Transfer”, First Edition (Tata McGraw-Hill, 2002) FP Incropera and DP DeWitt, “Fundamentals of Heat and Mass Transfer”, Fifth Edition (*Wiley-India, 2007*)
Additional information (if any)
Student responsibilities Attendance, feedback, discipline: as per university rules.

Course reviewers

1. Dr. Maddali Ramgopal, Professor, Mechanical Engineering, Indian Institute of Technology Kharagpur
2. Dr. Arvind Pattamatta, Associate Professor, Department of Mechanical Engineering, Indian Institute of Technology Madras