Course title: Heat transfer			
Course code: ENR 192	**No. of credits:** 3	**L-T-P:** 33-12-0	**Learning hours:** 45
Pre-requisite course code and title (if any): N.A.			
Department: Sustainable Engineering			
Course coordinator: Dr. Ramkishore Singh	**Course instructor(s):** Prof. S C Mullick/ Dr Ramkishore Singh		
Contact details: ramkishore.singh@terisas.ac.in			
Course type: Programme 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 and their analysis. The course also covers basics of boiling and condensation on different surfaces.

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** Derivation of general heat conduction equation for constant properties, initial and boundary conditions 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	8	2	0
3	**Convection** Physical mechanisms of convection Velocity and Thermal boundary layer, external and internal forced convection underlaminar and turbulent flow conditions Laminar and turbulent natural convection over surfaces, natural convection inside enclosures	8	4	0

4	**Heat Exchangers**			
	Different types of heat exchangers: tube-in-tube, shell-and-tube, plate exchangers: parallel, counter and cross-flow configurations, overall heat transfer coefficient, fouling factors Analysis of heat exchangers: logarithmic mean temperature difference (LMTD) method, effectiveness-NTU method	4	2	
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, Solar radiation	6	2	0
6	**Boiling and Condensation** Pool boiling curve, nucleate boiling, critical heat flux, flow boiling, boiling heat transfer correlations Film-wise and drop-wise condensation, estimation of heat transfer coefficients for condensation on surfaces, condensation on tube and on tube banks	5	2	0
		33	12	

Evaluation criteria:

- Assignments: 20% (During Module 2-5)
- Minor test 1: 15% (after Module 2)
- Minor test 2: 15% (after Module 4)
- Major test: 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 Minor test 1)
- Model heat transfer problems and solve it (Minor test 1,2, Major test)
- Develop the skill to analyse heat exchangers, their sizing and selection (Minor test 2, Major test)

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 De Witt, "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

- Dr. Maddali Ramgopal, Professor, Mechanical Engineering, Indian Institute of Technology Kharagpur
- Dr K B Rana, Rajasthan Technical University, Kota, Rajasthan