Course No.: ENR 137
Course title: Heat and mass transfer
Number of credits: 6
Number of lectures-tutorial-lab: 66-18-0
Course coordinator: Prof. R L Sawhney

Course outline

The course is designed to familiarize the students with the basic principles of heat and mass transfer mechanisms and applications. Students will learn in detail (i) the basic concepts of heat transfer, conduction, convection and radiation, (ii) how their combinations contribute in any heat transfer process., and how a heat transfer process can be made more efficient and how to reduce heat losses. Besides he would also know about types of heat exchangers, their analysis, selection and sizing; basics of condensation and boiling, basics of natural and forced convection, black body radiation, estimation of radiative heat exchange between two hot black and gray bodies. The mass transfer mechanism which, from analysis point of view is very similar to heat transfer mechanism but very different applications has also been included in the paper discussed. Basic concepts related to mass transfer through diffusion and mass convection have been dealt in details. Application of mass transfer simultaneously along with heat transfer in various unit processes of evaporation, distillation, absorption, adsorption, humidification, dehumidification, drying etc. has also been described.

Evaluation procedure

- Assignments : 20%
- Two Minor Exams : 20% each
- Major Exam : 40%

Details of course contents and allotted time

	Contents	Allotted time (hrs)		
		L	T	P
1.	**Fundamentals of Heat Transfer:** Relevance of heat transfer to use of renewable energy sources, heat transfer mechanisms: conduction, convection, radiation	2	0	0
2.	**Conduction**: One-dimensional heat conduction equation, steady state one dimensional heat conduction in uniform solids and composite systems of rectangular, cylindrical and spherical geometries, concept of thermal resistance, electrical analogy, thermal contact resistance, critical thickness of insulation, multi-dimensional heat conduction in solids: shape factor Heat transfer from extended surfaces, fin efficiency and effectiveness Transient heat conduction, lumped system analysis, time constant, unsteady one dimensional and multidimensional heat conduction through rectangular, cylindrical and spherical geometries.	12	4	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.	14	4	0

5.	**Boiling and Condensation:**	6	2	0
	Pool boiling, boiling curve, nucleate and film boiling, flow boiling, estimation of heat transfer coefficients in nucleate boiling, at peak and minimum heat flux conditions and film boiling; film-wise and drop-wise condensation, estimation of heat transfer coefficients for condensation on surfaces, condensation inside tubes and horizontal and vertical tube banks, principal and construction of heat pipe			
6.	**Heat Exchangers:**	8	2	0
	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.			
7.	**Radiation:**	10	2	0
	Thermal radiation, blackbody radiation spectrum analysis, radiative properties: emissivity, absorptivity, reflectivity and transmittivity; View factor algebra: reciprocity relation, summation rule, superposition rule and symmetry rule, radiative heat transfer between black and gray surfaces, radiation shields			
8.	**Fundamentals of Mass Transfer:**	14	4	0
	Analogy between heat and mass transfer, basics of mass diffusion, Fick law, diffusion coefficients in solids, liquids and gases; Henry's and Roult's laws; steady mass diffusion through slabs, cylindrical shells and spherical shells; vapour migration through walls and doors; transient mass diffusion, penetration depth; Diffusion of vapor through stationary gases (Stefan flow); Mass convection; analogy between friction, heat transfer and mass transfer coefficients; simultaneous heat and mass transfer; applications of heat and mass transfer in unit processes involving evaporation, distillation, absorption, adsorption, humidification, dehumidification, drying etc.			
	Total	66	18	0

Text Books:
- FP Incropera and DP DeWitt: **Fundamentals of Heat and Mass Transfer**, Fifth Edition, (*Wiley-India, 2007*).
- YA Cengel: **Heat and Mass Transfer: A practical approach,** Third Edition (Tata McGraw Hill)

Reference Books:
- JP Holman: **Heat Transfer**, Ninth Edition (*Tata McGraw-Hill, 2007*)
- PK Nag: **Heat Transfer**, First Edition (*Tata McGraw-Hill, 2002*)
- F Kreith: **Principles of Heat Transfer**, (*McGraw-Hill*)
- EB Woodruff, HB Lammers, TF Lammers: **Steam Plant Operation,** Eighth Edition (*McGraw-Hill, 2004*)
- PK Nag: **Power Plant Engineering**, Third Edition (*Tata McGraw-Hill, 2007*)

Reviewers:
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- **Prof. SC Mullick**, Professor, Centre for Energy Studies, IIT Delhi