## SEMESTER S4

# HEAT & MASS TRANSFER

| Course Code | PEPOT413 | CIE Marks | 40 |
|---|---|---|---|
| Teaching Hours/Week (L: T:P: R) | 3:0:0:0 | ESE Marks | 60 |
| Credits | 3 | Exam Hours | 2 Hrs. 30 Min. |
| Prerequisites (if any) | Basic knowledge in heat transfer and various unit operations. | Course Type | Theory |

**Course Objectives:**

1. To introduce the various modes of heat transfer and to develop methodologies for solving a wide variety of practical heat transfer problems
2. To familiarize about mass transfer and the various unit operations and its material balances.

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## SYLLABUS

| Module No. | Syllabus Description | Contact Hours |
|---|---|---|
| 1 | **Modes of heat transfer: -** laws governing heat transfer, thermal conductivity, general heat conduction equation in Cartesian coordinates, Fourier heat conduction equation, thermal conductivity of solids, liquids and gases- comparison between them, effect of temperature on thermal conductivity, thermal diffusivity, conduction through systems of constant thermal conductivity - conduction through plane and composite walls. Critical thickness of insulation. | 9 |

| | | |
|---|---|---|
| **2** | **Convection thermal boundary layer concept: -** individual and overall heat transfer coefficients, Dimensional analysis - Rayleigh and Buckingham's pi theorem, its limitations, application of dimensional analysis to forced convection.<br><br>**Introduction to heat exchangers: -** types of heat exchangers-the overall heat transfer coefficient-LMTD analysis of heat exchangers-<br><br>**Physical mechanism of radiation heat transfer-Radiation properties-;** Black body radiation Planck's law, Wein's displacement law, Stefan Boltzmann law, Kirchoff's law; | **9** |
| **3** | **Molecular diffusion: -** diffusion in liquids and gases, Ficks law, diffusivity of gases and liquids, steady state and equimolar counter diffusion in gases and liquids, analogies between heat and mass transfer, Daltons law, Henrys law, Raoult's law, ideal and non- ideal liquid solutions, various unit operations and material balances- drying, absorption, distillation, evaporation, leaching.<br><br>**Drying: -** equilibrium moisture content, bound and unbound moisture, critical moisture content, time of drying, rate of drying, drying curves, equipment for drying. | **9** |
| **4** | **Gas absorption: -** tray, spray and packed column, types and properties of tower packings, solubility of gas in a liquid and choice of solvent.<br><br>**Distillation: -** plate efficiency, rectification, construction of fractionating column, determination of theoretical plates by McCabe Thiele method, relative volatility.<br><br>**Evaporation: - single** and multiple effect evaporators, performance of evaporators, boiling point elevation, Duhrings rule, methods of feeding. | **9** |

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**Course Assessment Method (CIE: 40 marks, ESE: 60 marks)**

**Continuous Internal Evaluation Marks (CIE):**

| Attendance | Assignment/ Microproject | Internal Examination-1 (Written) | Internal Examination-2 (Written) | Total |
|---|---|---|---|---|
| 5 | 15 | 10 | 10 | 40 |

**End Semester Examination Marks (ESE)**

*In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions*

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| Part A | Part B | Total |
|---|---|---|
| • 2 Questions from each module.<br>• Total of 8 Questions, each carrying 3 marks<br>**(8x3 =24marks)** | • Each question carries 9 marks.<br>• Two questions will be given from each module, out of which 1 question should be answered.<br>• Each question can have a maximum of 3 sub divisions.<br>**(4x9 = 36 marks)** | **60** |

## Course Outcomes (COs)

At the end of the course students should be able to:

| Course Outcome | | Bloom's Knowledge Level (KL) |
|---|---|---|
| **CO1** | Interpret and compare various modes of heat transfer and examine the mechanisms involved | **K2** |
| **CO2** | Apply appropriate governing equations and analyse conduction heat transfer problems for different geometries under steady state processes | **K3** |
| **CO3** | Discover the concepts behind radiation heat transfer and solve convection heat transfer problems | **K4** |
| **CO4** | Analyse fundamentals of mass transfer operations and estimate diffusion coefficients | **K5** |
| **CO5** | Summarize interface mass transfer and concepts of mass transfer coefficients | **K2** |

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

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**CO-PO Mapping Table:**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | **2** | **2** | **1** | | | | | | | | | |
| **CO2** | **2** | **3** | | | | | **1** | | | | | |
| **CO3** | **2** | **2** | **3** | | | | | | | | | |
| **CO4** | **2** | **3** | | | | | | | | | | |
| **CO5** | **2** | **3** | | | | | | | | | | |

| Text Books | | | | |
|---|---|---|---|---|
| **Sl. No** | **Title of the Book** | **Name of the Author/s** | **Name of the Publisher** | **Edition and Year** |
| 1 | Heat and Mass Transfer | R. K Rajput | S. Chand | 2007 |
| 2 | Mass Transfer, Theory and Applications. | K.V.Narayanan and B. Lakshmikutty | CBS Publishers | 2nd Edition |
| 3 | Heat and Mass Transfer. | D.S Kumar | Kataria& Sons | 2009 |
| 4 | Principles of Mass Transfer and Separation Processes | Binay K Dutta | PHI Learning Pvt. Ltd. | 2015 |

| Reference Books | | | | |
|---|---|---|---|---|
| **Sl. No** | **Title of the Book** | **Name of the Author/s** | **Name of the Publisher** | **Edition and Year** |
| 1 | Mass Transfer Operations | Robert E | McGraw Hill | 1980 |
| 2 | Introduction to Chemical Engineering. | Badger | Tata Mc Graw-Hill | 1984 |
| 3 | Unit operations of chemical Engineering | Warren L McCabe, Julian C Smith, P Harriot | McGraw Hill | (7thed.) 2005 |

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| Video Links (NPTEL, SWAYAM…) | |
|---|---|
| **Module No.** | **Link ID** |
| 1 | Heat and Mass Transfer, Prof. S.P. Sukhatme, Prof. U.N. Gaitonde -IIT Bombay<br>https://nptel.ac.in/courses/112101097 |
| 2 | Convective Heat and Mass Transfer, Prof. A.W. Date- IIT Bombay<br>https://nptel.ac.in/courses/112101002 |
| 3 | Mass Transfer Operations -I, Dr. B. Mandal -IIT Guwahati<br>https://nptel.ac.in/courses/103103034 |
| 4 | Mass Transfer II, Prof. Nishith Verma -IIT Kanpur<br>https://nptel.ac.in/courses/103104046 |