# GUJARAT TECHNOLOGICAL UNIVERSITY

**Bachelor of Engineering**
**Subject Code: 3142111**
**Semester – IV**
**Subject Name: Phase Transformations**

**Type of course:** Science & Engineering

**Prerequisite:** Knowledge of Materials Thermodynamics & Transport Phenomena.

**Rationale:** The aim of this course is to gain an understanding of the role of phase transformations on the development of microstructure and properties of metallic materials. The course will highlight a number of commercially-significant applications where phase transformations are important.

**Teaching and Examination Scheme:**

| Teaching Scheme | | | Credits | Examination Marks | | | | Total Marks |
|---|---|---|---|---|---|---|---|---|
| | | | | Theory Marks | | Practical Marks | | |
| L | T | P | C | ESE (E) | PA (M) | ESE (V) | PA (I) | |
| 2 | 0 | 4 | 4 | 70 | 30 | 30 | 20 | 150 |

**Content:**

| Sr. No. | Content | Total Hrs | % Weightage |
|---|---|---|---|
| 1 | **Module 1**: Definition and types of Phase transformations. | **01** | 05 |
| 2 | **Module 2:** Diffusion: Fick's laws of diffusion, solution of Fick's second law and its applications, atomic model of diffusion and role of crystal defects, temperature dependence of diffusion coefficient. | **04** | 15 |
| 3 | **Module 3**: Kirkendall effect. Diffusional transformation in solids and diffusionless transformation in solids. | **04** | 15 |
| 4 | **Module 4**: Nucleation and growth - energy considerations; homogeneous nucleation, heterogeneous nucleation, growth kinetics, overall transformation rates. | **04** | 15 |
| 5 | **Module 5:** Crystal interfaces and microstructure. Microstructure evolution including recrystallization and grain growth. | **03** | 10 |
| 6 | **Module 6:** Precipitation from solid solution: Homogeneous and hetrogeneous nucleation of precipitates, the aging curve, mechanisms of age hardening, examples from Al-Cu and other alloy systems. | **03** | 10 |
| 7 | **Module 7:** Martensitic Transformations: General characteristics of martensitic reactions, similarity to deformation twinning, bain distortion, crystallography and kinetics of martensitic transformations, examples from ferrous and non-ferrous alloy systems. | **04** | 15 |
| 8 | **Module 8:** Order-disorder Transformation Examples of ordered structures, long and short range order, detection of super lattices, influence of ordering on properties. | **04** | 10 |
| 9 | **Module 9:** Spinodal decomposition | **01** | 05 |

| | | | |
|---|---|---|---|
| | Total | **28** | 100 |

**Suggested Specification table with Marks (Theory):**

| **Distribution of Theory Marks** | | | | | |
|---|---|---|---|---|---|
| R Level | U Level | A Level | N Level | E Level | C Level |
| **25** | **35** | **20** | **10** | **05** | **05** |

**Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)**

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

**Reference Books:**

1. Solid State Phase Transformations, V. Raghavan, Prentice Hall India Learning Private Limited, 1987.
2. Phase Transformations in Metals and Alloys, David A. Porter and Kenneth E. Easterling, Third Edition, CRC Press, 2017.
3. Physical Metallurgy Principles, Reza Abbaschian, Lara Abbaschian, and Robert E. Reed- Hill, Cengage, 2013
4. Mechanisms of Diffusional Phase Transformations in Metals and Alloys, Hubert I. Aaronson, Masato Enomoto, and Jong K. Lee, CRC Press, 2016.

**Course Outcomes:**

| **Sr. No.** | **CO statement** | **Marks % Weightage** |
|---|---|---|
| CO-1 | Understanding of the principles underlying liquid-solid and solid-state phase transformations in a range of materials. | 35 |
| CO-2 | Apply the laws in metallurgical processes and problem solving skill in material science and engineering. | 35 |
| CO-3 | Analyze phase transformations occur in engineering alloys for controlling microstructure and properties. | 30 |

**List of Experiments:**

1. Introduction to phase transformation and their classifications.
2. To study about application of thermodynamics and kinetics in phase transformations.
3. Demonstration of diffusional transformation in liquid and analog with solid.
4. To study about nucleation and growth.
5. To study phase diagram and exercise based precipitation from solid solution.
6. To calculate amount of phases using Lever rule.
7. To Solve Numerical problems based on diffusion and Phase transformation.

8. To analyze microstructures of diffusion and diffusion-less phase transformation.
9. To prepare chart of order- disorder transformation and spinodal decomposition with suitable examples.

**Major Equipment:** Nil

**List of Open Source Software/learning website:**

1. Diffusion in solids by Prof. Alok Paul , IISC Bangalore (NPTEL Web Course)
2. www.ocw.mit.edu