COURSE STRUCTURE & DETAILED SYLLABUS

OF

METALLURGICAL ENGINEERING

FOR

B.TECH. FOUR YEAR DEGREE COURSE

(Applicable for the batches admitted from 2023-2024)

DEPARTMENT OF METALLURGICAL ENGINEEERING

NETAJI SUBHAS UNIVERSITY, JAMSHEDPUR

Jharkhand, India

METALLURGICAL ENGINEERING DEPARTMENT

VISION

To impart quality education in Metallurgical Engineering and constantly pursuing excellence by upgrading knowledge skills and attitude useful to Industry, Academic and Society.

MISSION

1. To produce graduates having professional excellence in Basic Sciences and Metallurgical Engineering with concern towards society
2. To provide a scientific environment, to help meet the desires and needs of students and faculty for enhancing research efforts and technological innovations.
3. To provide technical support to higher education, industry and R&D units.

Program Educational Objectives (Metallurgical Engineering)

The Metallurgical Engineering program at NSU prepares graduates who can

PEO 1

Obtain good and high positions in public or private institutions as engineers and researchers.

PEO 2

Follow higher education in prestigious universities and have a successful academic career.

PEO 3

Demonstrate advancement in their chosen career by upgrading their skills continuously.

PEO 4

Exhibit high ethical standards and responsibilities towards their profession and society.

Program Outcomes (Metallurgical Engineering)

PO 1	**Engineering Knowledge:** Knowledge of mathematics, science, and engineering fundamentals and ability to apply them to solve complex metallurgical phenomena.
PO 2	**Problem Analysis:** Identification and analysis of process - structure – property – performance correlation of metals and materials with the knowledge of science and engineering principles.
PO 3	**Design/Development of solutions:** Ability to design material systems, components, process to meet the desired needs within the realistic constraints of economic, public safety, environmental, manufacturability, and sustainability.
PO 4	**Conduct Investigations of Complex problems:** Design, conduct, analyze, and interpret the results of tests and researches in the field of metallurgical engineering and propose appropriate measures for efficient capacity utilization of systems; components and equipment etc. with minimum energy and rejects.
PO 5	**Modern Tool Usage:** Select and apply appropriate methods for analysis and characterization of materials to check the quality and performance and usage of modern tools to address the specific needs of metallurgical industries.

PO 6	**The Engineer and Society:** Propose appropriate measures for protection and modifying equipment, systems and processes from damage, degradation and inefficiency due to various physical, chemical and mechanical environments.
PO 7	**Environment and Sustainability:** Understanding the impact of various metallurgical processes on environment and suggest appropriate measures for viable alternatives and taking measures for reuse, recycle and reclamation of rejects and byproducts.
PO 8	**Ethics:** An understanding of professional and ethical responsibility towards engineering practice and profession.
PO 9	**Individual and Team Work:** Ability to function in diverse teams and works.
PO 10	**Communication:** Ability to effectively communicate in professional context through oral presentations and written technical reports as well as successfully work in group oriented tasks.
PO 11	**Project Management and Finance:** Demonstrate the fundamental knowledge and skills associated with technical and management principles and application of them at individual and as member or a leader of a team and in multidisciplinary environment at various platforms.
PO 12	**Life-Long Learning:** Recognition of the need; ability and awareness to engage independently and exhibit creativity; innovations and proactive demeanor for engaging in lifelong learning.

Program Specific Outcomes (Metallurgical Engineering)

PSO 1

Apply metallurgical principles to provide ecological and cost effective solutions for metal extraction and refining industries and manufacturing industries.

PSO 2

Identify, evaluate and modify existing materials and their behaviour with respect to structure – property – processing – performance applications and develop new materials that are sustainable, economical and eco-friendly with tailor made properties and applications.

PSO 3

Understand, evaluate, modify and design existing manufacturing processes, characterization techniques and develop new processes to specific engineering applications and ensure reliable and sustainable products.

NETAJI SUBHAS UNIVERSITY, JAMSHEDPUR

B.Tech. in METALLURGICAL ENGINEERING

I YEAR 1st SEMESTER

Code No.	Name of the Subjects	Periods			Credits	Marks		
		L	T	P		IA	TE	TM
BT 101	Engineering Mathematics-I	3	1	-	4	30	70	100
BT 102	Engineering Physics	4	-	-	4	30	70	100
BT 103	Programming in C	4	-	-	4	30	70	100
BT 104	Elements of Mechanical Engineering	3	-	-	4	30	70	100
BT 105	Basic of Electrical Engineering	3	-	-	4	30	70	100
BT 106	Professional Communication Skill	3	-	-	3	30	70	100
	Practical							
BT 107L	Engineering Physics Lab	-	-	4	2	15	35	50
BT 108L	Programming in C Lab	-	-	4	2	15	35	50
	Total	**20**	**1**	**8**	**27**	**210**	**490**	**700**

I YEAR 2nd SEMESTER

Code No.	Name of the Subjects	Periods			Credits	Marks		
		L	T	P		IA	TE	TM
BT 201	Engineering Mathematics-II	3	1	-	4	30	70	100
BT 202	Engineering Chemistry	4	-	-	4	30	70	100
BT 203	Basic Elements of Civil Engineering and Mechanics	4	-	-	4	30	70	100
BT 204	Computer Aided Engineering Drawing	4	-	-	4	30	70	100
BT 205	Basic Electronics	4	-	-	3	30	70	100
BT 206	Software Engineering	3	1	-	3	30	70	100
	Practical							
BT 207L	Engineering Chemistry Lab	-	-	4	2	15	35	50
BT 208L	Workshop Practice	-	-	4	2	15	35	50
	Total	**22**	**2**	**8**	**26**	**210**	**490**	**700**

B.Tech. in METALLURGICAL ENGINEERING

II YEAR 3rd SEMESTER

Code	Name of the Subject	Periods			Credits	Marks		
		L	T	P		IA	TE	TM
BTMT301	Engineering mathematics – III	3	1	-	4	30	70	100
BTMT302	Mineral Processing	4	-	-	3	30	70	100
BTMT303	Non- Ferrous Process Metallurgy	4	-	-	4	30	70	100
BTMT304	Metallurgical Thermodynamics - I	4	-	-	4	30	70	100
BTMT305	Physical Metallurgy	3	1	-	4	30	70	100
BTMT306	Materials Characterization Techniques	3	1	-	3	30	70	100
	Practical							
BTMT307L	Physical Metallurgy Lab	-	-	4	2	15	35	50
BTMT308L	Mineral Processing Lab	-	-	4	2	15	35	50
	Total	**24**	**3**	**8**	**26**	**210**	**490**	**700**

II YEAR 4th SEMESTER

Code	Name of the Subject	Periods			Credits	Marks		
		L	T	P		IA	TE	TM
BTMT401	Ceramics and Composite Materials	3	1	-	4	30	70	100
BTMT402	Metallurgical Thermodynamics - II	4	-	-	3	30	70	100
BTMT403	Principles of Extractive Metallurgy	4	-	-	3	30	70	100
BTMT404	Fuels, Furnaces and Refractories	4	-	-	4	30	70	100
BTMT405	Iron Making	3	1	-	4	30	70	100
BTMT406	Powder Metallurgy	3	1	-	3	30	70	100
	Practical							
BTMT407L	Fuels, Furnaces and Refractories Lab	-	-	4	2	15	35	50
BTMT408L	Principles of Extractive Metallurgy Lab	-	-	4	2	15	35	50
	Total	**21**	**3**	**8**	**25**	**210**	**490**	**700**

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III YEAR 5TH SEMESTER

Code	Name of the Subject	Periods			Credits	Marks		
		L	T	P		IA	TE	TM
BTMT501	Business Economics & Financial Analysis	3	-	-	3	30	70	100
BTMT502	Light Metals & Alloys	3	1	-	4	30	70	100
BTMT503	Heat Treatment and Phase Transformations	3	-	-	3	30	70	100
BTMT504	Metal Casting	3	-	-	3	30	70	100
BTMT505	Steel Making	3	1	-	4	30	70	100
BTMT506	Intellectual Property Rights	3	-	-	3	30	70	100
	Practical							
BTMT507L	Metal Casting Lab	-	-	4	2	15	35	50
BTMT508L	Heat Treatment and Phase Transformations Lab	-	-	4	2	15	35	50
	Total	**18**	**2**	**8**	**24**	**210**	**490**	**700**

III YEAR 6TH SEMESTER

Code	Name of the Subject	Periods			Credits	Marks		
		L	T	P		IA	TE	TM
BTMT601	Non Ferrous Extractive Metallurgy	3	-	-	4	30	70	100
BTMT602	Metal Forming	3	-	-	3	30	70	100
BTMT603	Metal Joining	3	-	-	3	30	70	100
BTMT604	**Elective – I** 1. Computational Materials Engineering 2. Ferro Alloy Technology	3	-	-	4	30	70	100
BTMT605	Environmental Science	3	-	-	4	30	70	100
BTMT606	Surface Engineering	3	1	-	4	30	70	100
	Practical							
BTMT607L	Metal Forming Lab	-	-	4	2	15	35	50
BTMT608L	Metal Joining Lab	-	-	4	2	15	35	50
	Total	**18**	**1**	**12**	**24**	**210**	**490**	**700**

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IV YEAR 7TH SEMESTER

Code	Name of the Subject	Periods			Credits	Marks		
		L	T	P		IA	TE	TM
BTMT701	Introduction to Instrumentation	4	-	-	3	30	70	100
BTMT702	Environmental Degradation of Materials	3	1	-	4	30	70	100
BTMT703	**Elective – II** 1. Nuclear Metallurgy 2. Electronic Materials	3	-	-	4	30	70	100
BTMT704	Mechanical Metallurgy	3	-	-	3	30	70	100
BTMT705	**Elective – III** 1. Testing of Materials 2. Corrosion Process and Control	3	1	-	4	30	70	100
BTMT706	Industrial Visits /Trainings				2	100	-	100
	Practical							
BTMT707L	Environmental Degradation of Materials Lab	-	-	4	2	15	35	50
BTMT708L	Mechanical Metallurgy lab			4	2	15	35	50
	Total	**16**	**2**	**8**	**24**	**280**	**420**	**700**

IV YEAR 8TH SEMESTER

Code	Name of the Subject	Periods			Credits	Marks		
		L	T	P		IA	TE	TM
BTMT801	**Elective – IV** 1. Solidification Processing 2. Non Metallic Materials 3. Functional Materials 4. Alloy Steels	3	1	-	4	30	70	100
BTMT802	Bio Materials	3	-	-	4	30	70	100
BTMT803	Transport Phenomena	3	-	-	4	30	70	100
BTMT804	High Temperature Materials	3	1	-	3	30	70	100
BTMT805	Seminar	1	-		2	100	-	100
BTMT806	Comprehensive Viva Voce			3	2		100	100
BTMT807	Project Work			12	6	50	50	100
	Total	**13**	**2**	**15**	**25**	**270**	**430**	**700**

1st Year 1st Semester

Code No.	Name of the Subjects	Periods			Credits	Marks		
		L	T	P		IA	TE	TM
BT 101	Engineering Mathematics-I	4	-	-	4	30	70	100
BT 102	Engineering Physics	4	-	-	4	30	70	100
BT 103	Programming in C	4	-	-	4	30	70	100
BT 104	Elements of Mechanical Engineering	3	-	-	4	30	70	100
BT 105	Basic of Electrical Engineering	3	-	-	4	30	70	100
BT 106	Professional Communication Skill	3	-	-	3	30	70	100
	Practical							
BT 107L	Engineering Physics Lab	-	-	4	2	15	35	50
BT 108L	Programming in C Lab	-	-	4	2	15	35	50
	Total	**20**	**1**	**8**	**27**	**210**	**490**	**700**

ENGINEERING MATHEMATICS-I (BT101)

Subject Code	BT101	IA Marks	30
Number of Lecture Hours/Week	04	Term End Exam Marks	70
Total Number of Lecture Hours	60	CREDITS	04

Course Objectives:

To enable the students to apply the knowledge of Mathematics in various engineering fields by making them to learn the following:

CO 1: n^{th} derivatives of product of two functions and polar curves.
CO 2: Partial derivatives
CO 3: Vector calculus
CO 4: Reduction formulae of integration; to solve First order differential equations.
CO 5: Solution of system of linear equations, quadratic forms.

Module - 1

Differential Calculus -1: Determination of n^{th} order derivatives, Leibnitz's theorem (without proof)- problems. Taylor's and Maclaurin's theorems for function of one variable (statement only)- problems. Evaluation of Indeterminate forms.
Partial derivatives – Definition and simple problems, Euler'stheorem (without proof) – problems, total derivatives, partial differentiation of composite functions-problems. Definition and evaluation of Jacobian

Hours – **12**

Module -2

Differential Calculus -2

Polar Curves - angle between the radius vector and tangent, angle between two curves, Pedal equation of polar curves. Derivative of arc length - Cartesian, Parametric and Polar forms (without proof)- problems. Curvature and Radius of Curvature – Cartesian, Parametric, Polar and Pedal forms (without proof) -problems

Hours - **10**

Module-3

Integral Calculus: Reduction formulae - $\int Sin^n x\, dx, \int Cos^n x\, d, \int Sin^m x\, Cos^n x\, dx,$ (m and n are positive integers), evaluation of these integrals with standard limits (0 to $\pi/2$) and problems.

Module-4

First order Differential Equations: Exact, reducible to exact and Bernoulli's differential equations. Orthogonal trajectories in Cartesian and polar form. Simple problems on Newton's law of cooling.

Hours - **12**

Module-5

Linear Algebra-Rank of a matrix by elementary transformations, solution of system of linear equations - Gauss-elimination method, Gauss–Jordan method and Gauss-Seidel method, Linear transformation, Eigen values and Eigen vectors. diagonalization of a square matrix. Reduction of Quadratic form.

Hours - **11**

Course outcomes:

On completion of this course, students are able to-

- **`CO-1:** Use partial derivatives to calculate rates of change of multivariate functions.
- **CO-2:** Analyze position, velocity, and acceleration in two or three dimensionsusing the calculus of vector valued functions.
- **CO-3:** Recognize and solve first-order ordinary differential equations, Newton's law of cooling
- **CO-4:** Use matrices techniques for solving systems of linear equations in the different areas of Linear Algebra.

Course Outcome No	Statement	Knowledge Level (K)
CO1	Use partial derivatives to calculate rates of change of multivariatefunctions.	K1
CO2	Analyze position, velocity, and acceleration in two or three dimensions using the calculus of vector valued functions.	K3
CO3	Recognize and solve first-order ordinary differential	K6

	equations, Newton'slaw of cooling	
CO4	Use matrices techniques for solving systems of linear equations in the different areas of Linear Algebra.	K2

KL – Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1- Remember, K_2 – Understand, K_3 – Apply, K_4 – Analyze, K_5- Evaluate, K_6 – Create

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3			3				2	1			
CO2	2				1		1	3	3			
CO3	3		2	3				1	1			
CO4												
CO Average	2.66		2	3	1		1	2	1.66			

3 - High; 2 - Medium; 1 - Low

Text Books:

1. B.S.Grewal,**"Higher Engineering Mathematics"**, Khanna publishers, 42nd edition, 2013.
2. Erwin Kreyszig, **"Advanced Engineering Mathematics**I, Wiley, 2013

Reference Books:

1. B.V. Ramana, **"Higher Engineering Mathematics"**, Tata Mc Graw-Hill, 2006
2. N.P. Bali and Manish Goyal, **"A text book of Engineering mathematics"**, Laxmi publications, latest edition.
3. H.K. Dass and Er. Rajnish Verma, **"Higher Engineering Mathematics"**, S.Chand publishing, 1st edition, 2011.

ENGINEERING PHYSICS (BT102)

Subject Code	**BT102**	**IA Marks**	30
Number of Lecture Hours/Week	04	**Term End Exam Marks**	70
Total Number of Lecture Hours	60	**CREDITS**	04

COURSE OBJECTIVES:

CO 1:	To make students learn and understand basic concepts and principles of

	physics
CO 2:	To analyze practical engineering problems and apply its solutions effectively and meaningfully.
CO 3:	To understand building up of models, design issues, practical oriented skills and problem solving challenges arethe great task of the course.
CO 4:	To know about shock waves and practical applications is the prime motto to introduce new technology at the initial stage of Engineering.
CO 5:	To make students learn and understand basic concepts and principles of physics

Module 1: Quantum Mechanics

Introduction to quantum physics, Black body radiation, Planck's law, Photoelectric effect, Compton effect, de-Broglie's hypothesis, Wave-particle duality, Davisson and Germer experiment, Heisenberg's Uncertainty principle, Born's interpretation of the wave function, Schrodinger's time independent wave equation, Particle in one dimensional box.

Hours- 10

Module-2: Semiconductor Physics

Intrinsic and Extrinsic semiconductors, Dependence of Fermi level on carrier-concentration and temperature, Carrier generation and recombination, Carrier transport: diffusion and drift, Hall effect, p-n junction diode, Zener diode and their V-I Characteristics, Bipolar Junction Transistor (BJT): Construction, Principle of operation.

Hours- 10

Module-3: Optoelectronics

Radiative and non-radiative recombination mechanisms in semiconductors, LED and semiconductor lasers: Device structure, Materials, Characteristics and figures of merit, Semiconductor photodetectors: Solar cell, PIN and Avalanche and their structure, Materials, working principle and Characteristics.

Hours- 10

Module-4: Lasers and Fibre Optics

Lasers: Introduction to interaction of radiation with matter, Coherence, Principle and working of Laser, Population inversion, Pumping, Types of Lasers: Ruby laser, Carbon dioxide (CO2) laser, He-Ne laser, Applications of laser. Fibre Optics: Introduction, Optical fibre as a dielectric wave guide, Total internal reflection, Acceptance angle, Acceptance cone and Numerical aperture, Step and Graded index fibres, Losses associated with optical fibres, Applications of optical fibres.

Hours- 10

Module-5: Electromagnetism and Magnetic Properties of Materials

Laws of electrostatics, Electric current and the continuity equation, Ampere's and Faraday's laws, Maxwell's equations, Polarisation, Permittivity and Clausius-Mossotti equation, Ferroelectrics and Piezoelectrics. Magnetisation, permeability and susceptibility, Classification of magnetic materials,

Ferromagnetism and ferromagnetic domains, Hysteresis, Applications of magnetic materials. Dielectric constant, Internal fields in a solid,

Hours- **10**

Course outcomes:

On Completion of this course, students are able to –

- **CO-1:** Learn and understand more about basic principles and to develop problem solving skills and implementation in technology.
- **CO-2:** Gain Knowledge about Modern physics and quantum mechanics will updatethe basic concepts to implement the skills.
- **CO-3:** Study of material properties and their applications is the prime role to understand and use in engineering applications and studies.
- **CO-4:** Study Lasers and Optical fibers and its applications are to import knowledge and to develop skills and to use modern instruments in the engineering applications.
- **CO-5:** Understand Crystal structure and applications are to boost the technical skills and its applications.
- **CO-6:** Expose shock waves concept and its applications will bring latest technology to the students at the first year level to develop research orientation programs at higher semester level.
- **CO-7:** Understand basic concepts of nano science and technology.
- **CO-8:** Gain Knowledge about Modern physics and quantum mechanics will updatethe basic concepts to implement the skills.

Course Outcome No	Statement	Knowledge Level (K)
CO1	Learn and understand more about basic principles and to develop problem solving skills and implementation in technology.	K1
CO2	Gain Knowledge about Modern physics and quantum mechanics will update the basic concepts to implement the skills.	K3
CO3	Study of material properties and their applications is the prime role to understand and use in engineering applications and studies.	K6
CO4	Study Lasers and Optical fibers and its applications are to import knowledge and to develop skills and to use modern instruments in the engineering applications.	K2
CO5	Understand Crystal structure and applications are to boost the technical skills and its applications.	K3
CO6	Expose shock waves concept and its applications will bring latest technology to the students at the first year level to develop research orientation programs at higher semester level.	K5
CO7	Understand basic concepts of nano science and technology.	K1

KL – Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1- Remember, K_2 – Understand, K_3 – Apply, K_4 – Analyze, K_5- Evaluate, K_6 – Create

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3			3				2	1			
CO2	2				1		1	3	3			
CO3	3		2	3				1	1			
CO4												
CO Average	2.66		2	3	1		1	2	1.66			

3 - High; 2 - Medium; 1 - Low

Text Books:

1. Wiley precise Text, **Engineering Physics,** Wiley India Private Ltd., New Delhi. Book series – 2014,
2. Dr. M.N. Avadhanulu, Dr. P.G.Kshirsagar, Text Book of Engineering Physics**,** S Chand Publishing, New Delhi – 2012

PROGRAMMING IN C (BT103)

Subject Code	**BT103**	**IA Marks**	30
Number of Lecture Hours/Week	04	**Term End Exam Marks**	70
Total Number of Lecture Hours	60	**CREDITS**	04

COURSE OBJECTIVES:

1. Design solutions to simple engineering problem by applying the basic programming principles of C language and basic mathematical knowledge.
2. Choose a suitable C-construct to develop C code for a given problem.
3. Recognize the bugs in the C program.
4. Apply the C-language syntax rules to correct the bugs in the C program.
5. To make students learn and understand basic concepts and principles of physics
6. Design solutions to simple engineering problem by applying the basic programming principles of C language and basic mathematical knowledge.
7. Choose a suitable C-construct to develop C code for a given problem.

Module -1

Basics of Computer Hardware and Software

Basics of Computer Architecture: processor, Memory, Input& Output devices.

Application Software & System software: Compilers, interpreters, High level and low level languages, Introduction to structured approach to programming, Flow chart Algorithms, Pseudo code (bubble sort, linear search - algorithms and pseudo code)

Hours- 10

Module -2

Program Basics

Basic structure of C program: Character set, Tokens, Identifiers in C, Variables and Data Types, Constants, Console IO Operations, printf and scanf.

Operators and Expressions: Expressions and Arithmetic Operators, Relational and Logical Operators, Conditional operator, size of operator, Assignment operators and Bitwise Operators. Operators Precedence, Preprocessor directive.

Control Flow Statements: If Statement, Switch Statement, Unconditional Branching using goto statement, While Loop, Do While Loop, For Loop, Break and Continue statements.(Simple programs covering control flow)

Hours- 10

Module -3

Arrays and strings

Arrays Declaration and Initialization, 1-Dimensional Array, 2-Dimensional Array

String processing:

In built String handling functions (strlen, strcpy, strcat and strcmp, puts, gets). Linear search program, bubble sort program, simple programs covering arrays and strings.

Hours- 10

Module -4

Pointers

Basics of Pointer: declaring pointers, accessing data though pointers, NULL pointer, array access using pointers, pass by reference effect

Structure & Union

Introduction, Declaration and Initialization, Array of Structures, Unions.

Hours- 15

Module- 5

Working with functions

Introduction to modular programming, writing functions, formal parameters, actual parameters Pass by Value, Recursion, Arrays as Function Parameters structure, union, Storage Classes, Scope and life time of variables, simple programs using functions

File Handling

File Operations: open, close, read, write, append, Sequential access and random access to files:

In built file handling functions (rewind() ,fseek(), ftell(), feof(), fread(), fwrite()), simple programs covering pointers and files.

Hours- **15**

Course outcomes:

After the completion of this course, students will be able to:

- **CO-1:** Illustrate and explain the basic computer concepts and programming principles of C language.
- **CO-2:** Develop C programs to solve simple mathematical and decision making problems.
- **CO-3:** Develop C programs to solve simple engineering problems using looping constructs.
- **CO-4:** Develop C programs to demonstrate the applications of derived data types such as arrays, pointers, strings and functions

Course Outcome No	Statement	Knowledge Level (K)
CO1	Illustrate and explain the basic computer concepts and programming principles of C language.	K1
CO2	Develop C programs to solve simple mathematical and decision making problems.	K3
CO3	Develop C programs to solve simple engineering problems using looping constructs.	K6
CO4	Develop C programs to demonstrate the applications of derived data types such as arrays, pointers, strings and functions	K2

KL – Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1- Remember, K_2 – Understand, K_3 – Apply, K_4 – Analyze, K_5- Evaluate, K_6 – Create

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3			3				2	1			
CO2	2				1		1	3	3			
CO3	3		2	3				1	1			
CO4												
CO Average	2.66		2	3	1		1	2	1.66			

3 - High; 2 - Medium; 1 - Low

Text Books

1. Schaum Series, Gottfried B.S.,Tata McGraw Hill,Programming with C
2. E. Balagurusamy, Mcgraw Hill,Programming in ANSI C
3. Asok N Kamthane, Pearson,Programming in C

4. Anita Goel, Pearson, Computer Fundamentals

Elements of Mechanical Engineering (BT104)

Subject Code	BT104	IA Marks	30
Number of Lecture Hours/Week	03	Term End Exam Marks	70
Total Number of Lecture Hours	60	CREDITS	04

Course objectives:

1. Students belonging to all branches of Engineering are made to learn certain fundamental topics related to mechanical engineering so that they will have a minimum understanding of mechanical systems, equipment and process.

Module -1

Energy Resources: Non-renewable and renewable energy resources, Petroleum based solid, liquid and gaseous fuels, Calorific values of fuels, Combustion and combustion products of fuels.
Solar Power: Solar Radiation, Solar constant (definition only), Solar Thermal energy harvesting, ex: liquid flat plate collectors, solar ponds (principle of operation only), Solar photovoltaic principle.
Wind Power: principle of operation of a typical windmill.
Hydro Power: Principles of electric power generation from hydro power plants,
Nuclear Power: Principles of Nuclear power plants,
Bio Fuels: introduction to bio fuels, examples of various biofuels used in engineering applications, Comparison of biofuels with petroleum fuels in terms of calorific value and emission.
Hours- 10

Module- 2

Turbines and IC Engines and Pumps Steam turbines: Classification, Principle of operation of Impulse and reaction turbines, Gas turbines: Classification, Working principles and Operations of Open cycle and closed cycle gas turbines.

Water turbines: Classification, Principles and operations of Pelton wheel, Francis turbine and Kaplan turbine

Internal Combustion Engines: Classification, I.C. Engines parts, 2 Stroke and 4 stroke Petrol engines, 4 stroke diesel engines. P-V diagrams of Otto and Diesel cycles.

Problems on indicated power, brake power, indicated thermal efficiency, brake thermal efficiency, mechanical efficiency, andspecific fuel consumption.

Hours- **10**

Module- 3

Machine Tools Operations: Turning, facing, knurling, Thread cutting, Taper Turning , Drilling, Boring, Reaming, Tapping, Counter Sinking, Counter Boring, -Plane milling, End milling, Slot milling. (No sketches of Machine tools, sketches to be used only for explaining operations.)

Hours- **5**

Module-4

Engineering materials and joining processes: Engineering Materials: Types and applications of Ferrous & Nonferrous metals and alloys,
Composites: Definition, Classification and applications(Air craft and Automobiles)

Soldering, Brazing and Welding:

Definitions, classification and method of soldering, Brazing and welding. Differences between soldering, Brazing and Welding. Description of Electric Arc Welding and Oxy-Acetylene Welding.

Hours- **10**

Module-5

Refrigeration, Air-Conditioning:

Refrigerants: properties of refrigerants, list of commonly used refrigerants. Refrigeration –Definitions – Refrigerating effect, Ton of Refrigeration, Ice making capacity, COP, Relative COP, unit of Refrigeration. Principle and working of vapor compression refrigeration and vapour absorption refrigeration: Principles and applications of air conditioners, Room air conditioner.

Hours- **10**

Course outcomes:
Students shall be able to demonstrate knowledge associated with,

- **CO-1:** Various Energy sources, Boilers, Prime movers such as turbines and IC engines, refrigeration and air-conditioning systems
- **CO-2:** Metal removal process using Lathe, drilling, Milling Robotics and Automation.
- **CO-3:** Fair understanding of application and usage of various engineering materials

Course Outcome No	Statement	Knowledge Level (K)
CO1	Various Energy sources, Boilers, Prime movers such as turbines and IC engines, refrigeration and air-conditioning systems	K1
CO2	Metal removal process using Lathe, drilling, Milling Robotics and Automation.	K3
CO3	Fair understanding of application and usage of various engineering materials	K6

KL – Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1- Remember, K_2 – Understand, K_3 – Apply, K_4 – Analyze, K_5- Evaluate, K_6 – Create

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3			3				2	1			
CO2	2				1		1	3	3			
CO3	3		2	3				1	1			
CO4												
CO Average	2.66		2	3	1		1	2	1.66			

3 - High; 2 - Medium; 1 - Low

Text Books:

1. V.K.Manglik, "Elements of Mechanical Engineering", PHI Publications, 2013. (Module-1,2,4,5)
2. Mikell P.Groover, "Automation, Production Systems & CIM", 3rd Edition, PHI (Module -3)
3. K.R.Gopalkrishna, "A text Book of Elements of Mechanical Engineering"- Subhash Publishers, Bangalore. (Module -1,2,3,4,5)

Basic of Electrical Engineering (BT105)

Subject Code	BT105	IA Marks	30
Number of Lecture Hours/Week	03	Term End Exam Marks	70
Total Number of Lecture Hours	60	CREDITS	04

Course objectives:

1. Impart a basic knowledge of electrical quantities such as current, voltage, power, energy and frequency to understand the impact of technology in a global and societal context.
2. Provide working knowledge for the analysis of basic DC and AC circuits used in electrical and electronic devices.
3. Develop selection skill to identify the type of generators or motors required for particular application.
4. Highlight the importance of transformers in transmission and distribution of electric power.
5. Emphasize the effects of electric shock and precautionary measures.
6. Improve the ability to function on multi-disciplinary teams.

Module -1

Ohm's law and Kirchhoff's laws, analysis of series, parallel circuit by independent voltage sources, concept of power and energy, definition of magnetic circuit and analogy between electric and magnetic circuits, faradays laws of electromagnetic induction, concept of Network Theorem.

Hours- 10

Module -2

Single Phase A.C. Circuits: Average value, R.M.S. value, form factor and peak factor for sinusoidal wave form, Steady State Analysis of series R-L-C circuits. Concept of Reactance, Impedance, Susceptance, Admittance, Concept of Power Factor, Real, Reactive and Complex power, Illustrative Problems

Hours- 10

Module - 3

Single phase transformers: principle of operation, constructional features and emf equation. DC. Generator: principle of operation, constructional features, emf equation.

DC Motor: principle of operation, Back emf, torque equation.

Hours- 10

Module- 4

Three phase Induction Motor: principle of operation, types; Synchronous Machines: principle of operation of Synchronous generator and motor. EMF equation, Voltage regulation, Applications and starting of Synchronous motor. Introduction to single-phase induction Motor.

Hours- 10

Module-5

Electrical Installations: Components of LT Switchgear: Switch Fuse Unit (SFU), MCB, ELCB, Types of Wires and Cables, Earthing. Elementary calculations for energy consumption and battery backup.

Measuring Instruments: Construction and Principle of operation of dynamometer type wattmeter and single-phase induction type energy meter

Hours- 10

Course outcomes:

After the completion of the course, the student should be able

- **CO-1:** To predict the behavior of electrical and magnetic circuits.
- **CO-2:** Select the type of generator / motor required for a particular application.
- **CO-3:** Realize the requirement of transformers in transmission and distribution of electric power and other applications.
- **CO-4:** Practice Electrical Safety Rules & standards.
- **CO-5:** To function on multi-disciplinary teams

Course Outcome No	Statement	Knowledge Level (K)
CO1	To predict the behavior of electrical and magnetic circuits.	K1
CO2	Select the type of generator / motor required for a particular application.	K3
CO3	Realize the requirement of transformers in transmission and distribution of electric power and other applications.	K6
CO4	Practice Electrical Safety Rules & standards.	K3
CO5	To function on multi-disciplinary teams	K5

KL – Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1- Remember, K_2 – Understand, K_3 – Apply, K_4 – Analyze, K_5- Evaluate, K_6 – Create

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3			3				2	1			
CO2	2				1		1	3	3			
CO3	3		2	3				1	1			
CO4												
CO5												
CO Average	2.66		2	3	1		1	2	1.66			

3 - High; 2 - Medium; 1 - Low

Professional Communication Skill (BT106)

Subject Code	BT106	IA Marks	30
Number of Lecture Hours/Week	03	Term End Exam Marks	70
Total Number of Lecture Hours	60	CREDITS	03

Course Objective:

On completion of this course, the students will be able to.

1. To develop Writing skills in preparing business letters, report, memos, and proposals.To develop Oratory skills through public speaking
2. To understand importance of professional attire in corporate environment.
3. To get knowledge on various business etiquette and inculcate the etiquette for corporate fit.

Module-1: Concepts of Communications

Introduction: Definition and Process of Communication - Forms of Verbal and Non-verbal Communication.
Barriers of Communication: Communication Barriers and Overcoming Communication Barriers - Guidelines for Effective Communication.
Business Writing: Direct and Indirect approaches to Business Writing - Five Main Stages of Writing Business Messages.
Exercise: Role Play, Square Talk Activity.
Hours- 10

Module-2: Written Business Communication
External Communication: The Seven C's of Letter writing - Kinds of Business Letters - Business Reports and Proposals - Purpose of Business Reports.
Internal Communication: Format and Principles of Writing Memos - General Warning - Cautions.
Exercise: Preparation of Reports on different issues.
Hours- 10

Module-3: Oral Communication
Public Speaking: Types of Public Speaking - importance of Public Speaking.
Power Point Presentation: Planning the Presentation - Delivering the Presentation - Developing & Displaying Visual Aids - Handling Questions from the Audience.
Listening: Definition - Types of Listening Skills - Features of a Good Listener - Causes and effects of Poor Listening.
Exercise: Elocution and Extempore
Hours- 10

Module-4: Behavioral Techniques
Body Language: Facial Expressions - Body Posture - Gestures - Eye Movement - Touch and the use of Personal Space.
Business Attire and Grooming: Different types of Attire - Guidelines for Business Attire. Exercise: Power of Body Language, Charades.
Hours- 5

Module-5: Etiquettes
Etiquettes: Greeting Etiquette - Corporate Etiquette - Telephone Etiquette - E-mail Etiquette – Meeting Etiquette - Netiquette - Personal Etiquette - Social Etiquette - Dining Etiquette. Exercise: Introduction and Art of Conversation, Telephonic Activity.
Hours- 5

Course Outcomes:
At the end of the course, the students would be able to:

- **CO-1:** Develop knowledge, skills, and judgment around human communication that facilitate their ability to work collaboratively with others.
- **CO-2:** Understand and practice different techniques of communication.
- **CO-3:** Practice and adhere to the 7Cs of Communication.
- **CO-4:** Familiarize with different types of Communication.
- **CO-5:** Understand and practice Interview Etiquettes.

Course Outcome No	Statement	Knowledge Level (K)
CO1	Develop knowledge, skills, and judgment around human communication that facilitate their ability to work collaboratively with others.	K1
CO2	Understand and practice different techniques of communication.	K3
CO3	Practice and adhere to the 7Cs of Communication.	K6
CO4	Familiarize with different types of Communication.	K3
CO5	Understand and practice Interview Etiquettes.	K5

KL – Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1- Remember, K_2 – Understand, K_3 – Apply, K_4 – Analyze, K_5- Evaluate, K_6 – Create

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3			3				2	1			
CO2	2				1		1	3	3			
CO3	3		2	3				1	1			
CO4												
CO5												
CO Average	2.66		2	3	1		1	2	1.66			

3 - High; 2 - Medium; 1 - Low

TEXT BOOKS:
1. Meenakshi Raman and Prakash Singh, Business Communication, Oxford
2. **Lesikar:** Basic Business Communication, TMH
3. **David Irwin:** Effective Business Communications, Viva- Thorogood. Rajendra Pal, J S Korlaha
4. **HI:** Essentials of Business Communication: Sultan Chand & Sons, New Delhi

2nd SEMESTER

Code No.	Name of the Subjects	Periods			Credits	Marks		
		L	T	P		IA	TE	TM
BT 201	Engineering Mathematics-II	3	1	-	4	30	70	100
BT 202	Engineering Chemistry	4	-	-	4	30	70	100
BT 203	Basic Elements of Civil Engineering and Mechanics	4	-	-	4	30	70	100
BT 204	Computer Aided Engineering Drawing	4	-	-	4	30	70	100
BT 205	Basic Electronics	4	-	-	3	30	70	100
BT 206	Software Engineering	3	1	-	3	30	70	100
	Practical							
BT 207L	Engineering Chemistry Lab	-	-	4	2	15	35	50
BT 208L	Workshop Practice	-	-	4	2	15	35	50
	Total	**22**	**2**	**8**	**26**	**210**	**490**	**700**

Engineering Mathematics-II (BT201)

Subject Code	BT201	IA Marks	30
Number of Lecture Hours/Week	04	Term End Exam Marks	70
Total Number of Lecture Hours	60	CREDITS	04

Course objectives:
To enable students to apply the knowledge of Mathematics in various engineeringfields by making them to learn the following:

1. Ordinary differential equations
2. Partial differential equations
3. Double and triple integration
4. Laplace transform

Module-I

Linear differential equations with constant coefficients: Solutions of second and higher order differential equations - inverse differential operator method, method of undetermined coefficients and method of variation of parameters.

Hours- 10

Module-2

Differential equations-2:

Linear differential equations with variable coefficients: Solution of Cauchy's and Legendre's linear differential equations.

Nonlinear differential equations - Equations solvable for p, equations solvable for y, equations solvable for x, general and singular solutions, Clairauit's equations and equations reducible to Clairauit's form.

Hours- 10

Module-3

Partial Differential equations:

Formulation of Partial differential equations by elimination of arbitrary constants/functions, solution of non-homogeneous Partial differential equations by direct integration, solution of homogeneous Partial differential equations involving derivative with respect to one independent variable only.

Derivation of one dimensional heat and wave equations and their solutions by variable separable method.

Hours- 10

Module-4

Integral Calculus:

Multiple integrals: Beta and Gamma functions: definitions, Relation between beta and gamma functions and simple problems**.**

Evaluation of double and triple integrals. evaluation of double integrals by changing the order of integration and by changing into polar co-ordinates .Applications of multiple integrals to find area and volume.

Hours- 10

Module-5

Laplace Transform

Definition and Laplace transforms of elementary functions.

Laplace transforms of $e^{at}f(t)$, $t^n f(t)$ and f(t) (without proof), t periodic functions and unit-step function- problems

Inverse Laplace Transform

Inverse Laplace Transform - problems, Convolution theorem to find the inverse Laplace transforms (without proof) and problems, solution of linear differential equations using Laplace Transforms.

Hours- 10

Course outcomes:

On completion of this course, students are able to-

- **CO-1:** Solve differential equations of electrical circuits, forced oscillation of mass springand elementary heat transfer.
- **CO-2:** Solve partial differential equations
- **CO-3:** Evaluate double and triple integrals to find area, volume, mass and

moment ofinertia of plane and solid region.

- **CO-4:** Use curl and divergence of a vector valued functions in various applications ofelectricity, magnetism and fluid flows

Course Outcome No	Statement	Knowledge Level (K)
CO1	Solve differential equations of electrical circuits, forced oscillation of mass springand elementary heat transfer.	K1
CO2	Solve partial differential equations	K3
CO3	Evaluate double and triple integrals to find area, volume, mass and moment ofinertia of plane and solid region.	K6
CO4	Use curl and divergence of a vector valued functions in various applications ofelectricity, magnetism and fluid flows	K3

KL – Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1- Remember, K_2 – Understand, K_3 – Apply, K_4 – Analyze, K_5- Evaluate, K_6 – Create

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3			3				2	1			
CO2	2				1		1	3	3			
CO3	3		2	3				1	1			
CO4												
CO5												
CO Average	2.66		2	3	1		1	2	1.66			

3 - High; 2 - Medium; 1 - Low

Text Books:

1. **B. S. Grewal**," Higher Engineering Mathematics", Khanna publishers, 42nd edition, 2013.
2. **Kreyszig,** "Advanced Engineering Mathematics " -Wiley, 2013

Reference Books:

1. B.V.Ramana "Higher Engineering M athematics" Tata Mc Graw-Hill, 2006
2. N P Bali and Manish Goyal, "A text book of Engineering mathematics" , Laxmi publications, latest edition.
3. H. K Das and Er. Rajnish Verma ,"Higher Engineering Mathematics", S. Chand publishing,1st edition, 2011.

Engineering Chemistry (BT202)

Subject Code	**BT202**	**IA Marks**	30
Number of Lecture Hours/Week	04	**Term End Exam Marks**	70
Total Number of Lecture Hours	60	**CREDITS**	04

Course objectives:

To provide students with knowledge of engineering chemistry for building technical competence in industries, research and development in the following fields

1. Electrochemistry & Battery Technology.
2. Corrosion & Metal Finishing.
3. Fuels & Solar energy.
4. Polymers.
5. Water Technology & Nano Materials.

Module -1

Electrochemistry and Battery Technology

Electrochemistry: Introduction, Derivation of Nernst equation for electrode potential. Reference electrodes: Introduction, construction, working and applications of calomel and Ag / AgCl electrodes. Measurement of electrode potential using calomel electrode. Ion selective electrode: Introduction; Construction and working of glass electrode, determination of pH using glass electrode. Concentration cells: Electrolyte concentration cells, numerical problems.

Battery Technology: Introduction, classification - primary, secondary and reserve batteries. Characteristics - cell potential, current, capacity, electricity storage density, energy efficiency, cycle life and shelf life. Construction, working and applications of Zinc- Air, Nickel- metal hydride batteries. Lithium batteries: Introduction, construction, working and applications of Li-MnO2 and Li-ion batteries.

Fuel Cells: Introduction, difference between conventional cell and fuel cell, limitations & advantages. Construction, working & applications of methanol-oxygen fuel cell with H2SO4 electrolyte.

Hours- 10

Module -2

Corrosion and Metal Finishing:

Corrosion: Introduction, electrochemical theory of corrosion, galvanic series. Factors affecting the rate of corrosion: ratio of anodic to cathodic areas, nature of metal, nature of corrosion product, nature of medium – pH, conductivity, and temperature. Types of corrosion- Differential metal, differential aeration (Pitting and water line) and stress. Corrosion control: Inorganic coatings-Anodizing of Al and phosphating; Metal coatings-Galvanization and Tinning. Cathodic protection (sacrificial anodic and impressed current methods).

Metal Finishing: Introduction, Technological importance. Electroplating: Introduction, principles governing-Polarization, decomposition potential and overvoltage. Factors influencing the nature of

electro deposit-current density, concentration of metal ion & electrolyte; pH, temperature & throwing power of plating bath; additives- brighteners, levellers, structure modifiers & wetting agents. Electroplating of Nickel (Watt's Bath) and Chromium(decorative and hard). Electro less plating: Introduction, distinction between electroplating and electro less plating, electro less plating of copper & manufacture of double sided Printed Circuit Board with copper.

Hours- 10

Module – 3

Fuels and Solar Energy:

Fuels: Introduction, classification, calorific value- gross and net calorific values, determination of calorific value of fuel using bomb calorimeter, numerical problems. Cracking: Introduction, fluidized catalytic cracking, synthesis of petrol by Fishcher-Tropsch process, reformation of petrol, octane and cetane numbers., anti knocking agents, power alcohol & biodiesel.

Solar Energy: Introduction, utilization and conversion, photovoltaic cells- construction and working. Design of PV cells: modules, panels & arrays. Advantages & disadvantages of PV cells. Production of solar grade silicon: Union carbide process, purification of silicon (zone refining), doping of silicon-diffusion technique (n&p types).

Hours- 10

Module - 4

Polymers:

Introduction, types of polymerization: addition and condensation, mechanism of polymerization- free radical mechanism taking vinyl chloride as an example. Molecular weight of polymers: number average and weight average, numerical problems. Glass transition temperature (Tg): Factors influencing Tg-Flexibility, inter molecular forces, molecular mass, branching & cross linking and stereo regularity. Significance of Tg. Structure property relationship: crystallinity, tensile strength, elasticity & chemical resistivity. Synthesis, properties and applications of PMMA (plexi glass), Polyurethane and polycarbonate. Elastomers: Introduction, synthesis, properties and applications of Silicone rubber.

Hours- 10

Module-5

Water Technology and Nanomaterials:

Water Technology: Introduction, boiler troubles with disadvantages & prevention methods-scale and sludge formation, priming and foaming, boiler corrosion(due to dissolved O2, CO2 and MgCl2). Determination of DO, BOD and COD, numerical problems on COD. Sewage treatment: Primary, secondary (activated sludge method) and tertiary methods. Softening of water by ion exchange process.

Nano Materials: Introduction, properties (size dependent). Synthesis-bottom up approach (sol-gel, precipitation, gas condensation & chemical vapour condensation processes). Nano scale materials-carbon nano tubes, nano wires, fullerenes, dendrimers, nano rods, & nano composites.

Hours- 10

Course outcomes:

On completion of this course, students will have knowledge in:

- **CO-1:** Electrochemical and concentration cells. Classical & modern batteries and fuel cells.
- **CO-2:** Causes & effects of corrosion of metals and control of corrosion. Modification of surface properties of metals to develop resistance to corrosion, wear, tear, impact etc. by electroplating and electro less plating.
- **CO-3:** Production & consumption of energy for industrialization of country andliving standards of people. Utilization of solar energy for different usefulforms of energy.
- **CO-4:** Replacement of conventional materials by polymers for various applications.
- **CO-5:** Boiler troubles; sewage treatment and desalination of sea water, and
- **CO-6:** Over viewing of synthesis, properties and applications of nanomaterials.

Course Outcome No	Statement	Knowledge Level (K)
CO1	Electrochemical and concentration cells. Classical & modern batteries and fuel cells.	K1
CO2	Causes & effects of corrosion of metals and control of corrosion. Modification of surface properties of metals to develop resistance tocorrosion, wear, tear, impact etc. by electroplating and electro less plating.	K3
CO3	Production & consumption of energy for industrialization of country andliving standards of people. Utilization of solar energy for different usefulforms of energy.	K6
CO4	Replacement of conventional materials by polymers for various applications.	K3
CO5	Boiler troubles; sewage treatment and desalination of sea water, and	K2
CO6	Over viewing of synthesis, properties and applications of nanomaterials.	K4

KL – Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1- Remember, K_2 – Understand, K_3 – Apply, K_4 – Analyze, K_5- Evaluate, K_6 – Create

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3			3				2	1			
CO2	2				1		1	3	3			
CO3	3		2	3				1	1			

CO4												
CO5												
CO6												
CO Average	2.66		2	3	1		1	2	1.66			

3 - High; 2 - Medium; 1 - Low

Text Books:

1. B.S.Jai Prakash, R.Venugopal, Sivakumaraiah & Pushpa Iyengar., **"Chemistry for Engineering Students"**, Subhash Publications,Bangalore.
2. R.V.Gadag & A.Nityananda Shetty., **"Engineering Chemistry"**, I K International Publishing House Private Ltd. New Delhi.
3. P.C.Jain & Monica Jain.,**"Engineering Chemistry"**, Dhanpat Rai Publications, New Delhi.

Reference Books:

1. O.G.Palanna,**"Engineering Chemistry"**,Tata McGraw Hill Education Pvt.Ltd. New Delhi, Fourth Reprint.
2. G.A.Ozin & A.C. Arsenault, **"Nanochemistry A Chemical Approach toNanomaterials"**, RSC publishing, 2005.
3. **"Wiley Engineering Chemistry"**, Wiley India Pvt. Ltd. New Delhi. SecondEdition.

Basic Elements of Civil Engineering and Mechanics (BT203)

Subject Code	**BT203**	**IA Marks**	30
Number of Lecture Hours/Week	04	**Term End Exam Marks**	70
Total Number of Lecture Hours	60	**CREDITS**	04

COURSE OBJECTIVES:

1. To learn basics of Civil Engineering concepts and infrastructure development,
2. To solve problems involving Forces, loads and Moments and know their applications in allied subjects.

Module 1: Introduction to Civil Engineering & Engineering Mechanics
Introduction to Civil Engineering

Scope of different fields of Civil Engineering - Surveying, Building Materials, Construction Technology, Geotechnical Engineering, Structural Engineering, Hydraulics, Water Resources and Irrigation Engineering, Transportation Engineering, Environmental Engineering.

Infrastructure: Types of infrastructure, Role of Civil Engineer in the Infrastructural Development, Effect of the infrastructural facilities onsocio-economic development of a country. Roads: Classification of Roads and their functions, Comparison of Flexible and Rigid Pavements (Advantages and Limitations)

Bridges: Types of Bridges and Culverts, RCC, Steel and Composite Bridges

Dams: Different types of Dams based on Material, Structural behavior and functionality with simple sketches.

Introduction to Engineering Mechanics: Basic idealizations - Particle, Continuum and Rigid body; Newton's laws-Force and its characteristics, types of forces-Gravity, Lateral and its distribution on surfaces, Classification of force systems, Principle of physical independence, superposition, transmissibility of forces, Introduction to SI units. Couple, Moment of a couple, Characteristics of couple, Moment of a force, Equivalent force - Couple system; Numerical problems on moment of forces and couples, on equivalent force - couple system

Hours- 10

Module 2: Analysis of Concurrent Force Systems
Concepts: Resultants and Equilibrium

Composition of forces - Definition of Resultant; Composition of coplanar - concurrent force system, Parallelogram Law of forces, Principle of resolved parts; Numerical problems on composition of coplanar concurrent force systems.

Equilibrium of forces - Definition of Equilibrant; Conditions of static equilibrium for different force systems, Lami's theorem; Numerical problems on equilibrium of coplanar – concurrent and non-concurrent force systems.

Application- Static Friction in rigid bodies in contact

Types of friction, Laws of static friction, Limiting friction, Angle of friction, angle of repose; Impending motion on horizontal and inclined planes; Numerical Problems on single and two blocks on inclined planes

Hours- 10

Module - 3 Analysis of Non-Concurrent Force Systems
Concepts: Resultants and Equilibrium

Composition of coplanar - non-concurrent force system, Varignon's principle of moments; Numerical problems on composition of coplanar non-concurrent Force system.

Application-Support Reaction in beams

Types of Loads and Supports, statically determinate beams, Numerical problems onsupport reactions for statically determinate beams with Point load (Normal and inclined) and uniformly distributed and uniformly varying loads and Moments.

Hours- 10

Module 4 Centroids and Moments of Inertia of Engineering Sections:

Centroids

Introduction to the concept, centroid of line and area, centroid of basic geometrical figures, computing centroid for–T,L,I,Z and full/quadrant circular sections and their built up sections. Numerical problems

Moment of Inertia

Introduction to the concept, Radius of gyration, Parallel axis theorem, Perpendicular axis theorem, Moment of Inertia of basic planar figures, computing moment of Inertia for – T, L, I, Z and full/quadrant circular sections and their built up sections. Numerical problems

Hours- 10

Module 5: Kinematics

Concepts and Applications

Definitions – Displacement – Average velocity – Instantaneous velocity – Speed – Acceleration - Average acceleration – Variable acceleration – Acceleration due to gravity – Newton's Laws of Motion.

Rectilinear Motion–Numerical problems.

Curvilinear Motion – Super elevation – Projectile Motion – Relative motion – Numerical problems.

Motion under gravity – Numerical problems.

Hours- 10

Course outcomes

After a successful completion of the course, the student will be able to:

- **CO-1:** Know basics of Civil Engineering, its scope of study, knowledge about Roads, Bridges and Dams;
- **CO-2:** Comprehend the action of Forces, Moments and other loads on systems of rigid bodies;
- **CO-3:** Compute the reactive forces and the effects that develop as a result of the external loads;
- **CO-4:** Locate the Centroid and compute the Moment of Inertia of regular cross-sections.
- **CO-5:** Express the relationship between the motion of bodies and
- **CO-6:** Equipped to pursue studies in allied courses in Mechanics.

Course Outcome No	Statement	Knowledge Level (K)
CO1	Know basics of Civil Engineering, its scope of study, knowledge about Roads, Bridges and Dams;	K1
CO2	Comprehend the action of Forces, Moments and other loads on systems of rigid bodies;	K3
CO3	Compute the reactive forces and the effects that develop as a result of the external loads;	K6
CO4	Locate the Centroid and compute the Moment of Inertia of regular	K3

	cross- sections.	
CO5	Express the relationship between the motion of bodies and	K2
CO6	Equipped to pursue studies in allied courses in Mechanics.	K4

KL – Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1- Remember, K_2 – Understand, K_3 – Apply, K_4 – Analyze, K_5- Evaluate, K_6 – Create

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3			3				2	1			
CO2	2				1		1	3	3			
CO3	3		2	3				1	1			
CO4												
CO5												
CO6												
CO Average	2.66		2	3	1		1	2	1.66			

3 - High; 2 - Medium; 1 - Low

TEXT BOOKS

1. Elements of Civil Engineering and Engineering Mechanics by M.N. Shesha Prakash and Ganesh. B. Mogaveer, PHI Learning, 3rd Revised edition (2014)
2. Engineering Mechanics-Statics and Dynamics by A Nelson, Tata McGraw Hill Education Private Ltd, New Delhi, 2009.
3. Elements of Civil Engineering (IV Edition) by S.S. Bhavikatti, New Age International Publisher, New Delhi, 3rd edition 2009.

REFERENCES

1. Engineering Mechanics by S.Timoshenko, D.H.Young, and J.V.Rao, TATA McGraw-Hill Book Company, New Delhi
2. Beer FP and Johnson ER, "Mechanics for Engineers- Dynamics and Statics"- 3rd SI Metric edition, Tata McGraw Hill. - 2008

Computer Aided Engineering Drawing (BT204)

Subject Code	**BT204**	**IA Marks**	30
Number of Lecture Hours/Week	04	**Term End Exam Marks**	70
Total Number of Lecture Hours	60	**CREDITS**	04

Course objectives:

1. Engineering drawing is an important tool for all Engineers and for many others professionals. It is the language of Engineers. Engineering Drawing communicates all needed information from the engineer who designed a part to the workers who will manufacture it.
2. The aim of the subject is to equip students with the fundamentals of Computer Aided Engineering Drawing and to further the ability to communicate information by graphical means.

Module -1

Introduction to Computer Aided Sketching

Introduction, Drawing Instruments and their uses, BIS conventions, Lettering, Dimensioning and free hand practicing. Computer screen, layout of the software, standard tool bar/menus and description of most commonly used tool bars, navigational tools. Co-ordinate system and reference planes. of HP, VP, RPP & LPP. of 2D/3D environment. Selection of drawing size and scale. Commands and creation of Lines, Co-ordinate points, axes, poly-lines, square, rectangle, polygons, splines, circles, ellipse, text, move, copy, off-set, mirror, rotate, trim, extend, break, chamfer, fillet, curves, constraints viz. tangency, parallelism, inclination and perpendicularity. Dimensioning, line conventions, material conventions and lettering.

Hours- 10

Module -2

Orthographic projections

Introduction, Definitions - Planes of projection, reference line andconventions employed, Projections of points in all the four quadrants, Projections of straight lines (located in First quadrant/first angle only), True and apparent lengths, True and apparent inclinations to reference planes (No application problems).Orthographic Projections of Plane Surfaces (First Angle Projection Only)

Introduction, Definitions–projections of plane surfaces–triangle, square, rectangle, rhombus, pentagon, hexagon and circle, planes in different positions by change of position method only (No problems on punched plates and composite plates).

Hours- 10

Module-3

Projections of Solids (First angle Projection only)

Introduction, Definitions – Projections of right regular tetrahedron, hexahedron (cube), prisms, pyramids, cylinders and cones in different positions (No problems on octahedrons and combination solid).

Hours- 5

Module-4

Sections and Development of Lateral Surfaces of Solids

Introduction, Section planes, Sections, Section views, Sectional views, Apparent shapes

and True shapes of Sections of right regular prisms, pyramids, cylinders and cones resting with base on HP. (No problems on sections of solids)
Development of lateral surfaces of above solids, their frustums and truncations. (No problems on lateral surfaces of trays, tetrahedrons, spheres and transition pieces).
Hours- **5**

Module-5
Isometric Projection (Using Isometric Scale Only)
Introduction, Isometric scale, Isometric projection of simple plane figures, Isometric projection of tetrahedron, hexahedron(cube), right regular prisms, pyramids, cylinders, cones, spheres, cut spheres and combination of solids (Maximum of three solids).
Hours- **10**

Course outcomes:

After studying this course, the students will be able:

- **CO-1:** To demonstrate the usage of CAD software.
- **CO-2:** To visualize and draw Orthographic projections,Sections of solids and Isometric views of solids.
- **CO-3:** Students will evaluate their ability in applying various concepts to solvepractical problems related to engineering drawing.

Course Outcome No	Statement	Knowledge Level (K)
CO1	Students will be able to demonstrate the usage of CAD software.	K1
CO2	Students will be able to visualize and draw Orthographic projections,Sections of solids and Isometric views of solids.	K3
CO3	Students are evaluated for their ability in applying various concepts to solvepractical problems related to engineering drawing.	K6

KL – Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1- Remember, K_2 – Understand, K_3 – Apply, K_4 – Analyze, K_5- Evaluate, K_6 – Create

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3			3				2	1			
CO2	2				1		1	3	3			
CO3	3		2	3				1	1			
CO4												
CO Average	2.66		2	3	1		1	2	1.66			

3 - High; 2 - Medium; 1 - Low

TEXT BOOKS:

1. Engineering Drawing – N.D. Bhatt & V.M. Panchal, 48th edition, 2005 Charotar Publishing House, Gujarat.

2. "Computer Aided Engineering Drawing"by Dr. M H Annaiah, Dr C N Chandrappa and Dr B Sudheer Premkumar Fifth edition, New Age International Publishers

REFERENCE BOOKS:

1. Computer Aided Engineering Drawing – S. Trymbaka Murthy, - I.K. International Publishing House Pvt. Ltd., New Delhi, 3rd revised edition-2006.

2. Engineering Graphics - K.R. Gopalkrishna, 32nd edition, 2005- Subash Publishers Bangalore.

Basic Electronics (BT205)

Subject Code	**BT205**	**IA Marks**	30
Number of Lecture Hours/Week	04	**Term End Exam Marks**	70
Total Number of Lecture Hours	45	**CREDITS**	03

Course Objectives:

1. To study in detail about construction of several electronic devices.
2. To analyse the characteristics of various electronic devices and circuits.
3. To understand the internal structure and characteristics of Op-amp.
4. To learn about the linear and non-linear applications of Op-amp.

Module–1: Semi Conductors and Diodes:

Conductors, Semiconductors, Intrinsic Semiconductors, Extrinsic Semi-Conductors. Diode Theory: Basic Ideas, The ideal Diode, Forward and Reverse Bias, Diode Equation, Volt-Ampere Characteristic. Special diodes: symbol of zener diode, operation, V-I characteristics, symbol of photo diode, working principle, LED symbol and principle.

Hours- 10

Module–2: Rectifiers:

Half-wave Rectifier, Full-wave and Bridge Rectifier, derivation of Ripple factor, efficiency of Half-wave, full-wave and Bridge rectifiers. Merits and demerits of Half-wave, full-wave and Bridge rectifiers, Comparisons of rectifiers.

Hours- **10**

Module-3: Bipolar Junction Transistors:

Symbols of pnp and npn transistors and their working principles, Transistor currents, input and output characteristics of Common base configuration, Common Emitter configuration Transistor Switch, Amplifiers: working principles of Common base amplifier, Common Emitter amplifier, Common collector amplifier and their applications.

Hours- **10**

Module-4: Characteristics of Op-Amps:

Introduction to OP-amp, Op-amp Block Diagram, ideal and practical Op-amp specifications, 741 op-amp & its features, Op-Amp parameters & Measurement, Input & Out put off set voltages & currents, slew rates, CMRR, PSRR.

Hours- **7**

Module-5: Applications of Op-Amps:

Inverting and Non-inverting amplifier, Integrator and differentiator, Comparators.

Hours- **3**

Course Outcomes:

Students will be able to

- **CO-1:** Understand the semiconductor physics of the intrinsic, p and n materials.
- **CO-2:** Understand the function and operation of diodes, transistors and amplifiers.
- **CO-3:** Students will be aware of the architecture, functions & their applications of IC 741 OP-Amp

Course Outcome No	Statement	Knowledge Level (K)
CO1	Understand the semiconductor physics of the intrinsic, p and n materials.	K1
CO2	Understand the function and operation of diodes, transistors and amplifiers.	K3
CO3	Students will be aware of the architecture, functions & their applications of IC 741 OP-Amp	K6

KL – Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1- Remember, K_2 – Understand, K_3 – Apply, K_4 – Analyze, K_5- Evaluate, K_6 – Create

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3			3				2	1			
CO2	2				1		1	3	3			
CO3	3		2	3				1	1			
CO4												
CO Average	2.66		2	3	1		1	2	1.66			

3 - High; 2 - Medium; 1 – Low

Text Books:

1. Electronic Principles, Albert Malvino and David J Bates, 7th Edition, Tata McGraw –Hill.
2. Electronic Devices and Circuits Theory, Boyelstad, Pearson Education, 8th Edition, September 2011.
3. Op-Amps and Linear Integrated Circuits , - Ramakanth A. Gayakwad, PHI, 4th Edition, 2009
4. Linear Integrated Circuits – D. Roy Chowdhury, New Age International Pvt.Ltd., 2nd Edition, 2003.

Software Engineering (BT206)

Subject Code	**BT206**	**IA Marks**	30
Number of Lecture Hours/Week	03	**Term End Exam Marks**	70
Total Number of Lecture Hours	60	**CREDITS**	03

Course Objectives:

1. Understand the software life cycle models
2. Understand the importance of the software development process
3. Understand the importance of modeling and modeling languages
4. Design and develop correct and robust software products

Module -1

Introduction:

Introduction to Software Engineering, Software Components, Software Characteristics, Software Crisis, Software Engineering Processes, Similarity and Differences from Conventional Engineering Processes, Software Quality Attributes. Software Development Life Cycle (SDLC) Models: Water Fall Model, Prototype Model, Spiral Model, Evolutionary Development Models, Iterative Enhancement Models.

Hours- **10**

Module -2

Software Requirement Specifications (SRS) Requirement Engineering Process: Elicitation, Analysis, Documentation, Review and Management of User Needs, Feasibility Study, Information Modeling, Data Flow Diagrams, Entity Relationship Diagrams, Decision Tables, SRS Document, IEEE Standards for SRS.

Software Quality Assurance (SQA): Verification and Validation, SQA Plans, Software Quality Frameworks, ISO 9000 Models, SEI-CMM Model.

Hours- **10**

Module -3

Software Design: Basic Concept of Software Design, Architectural Design, Low Level Design: Modularization, Design Structure Charts, Pseudo Codes, Flow Charts, Coupling and Cohesion Measures, Design Strategies: Function Oriented Design, Object Oriented Design, Top-Down and Bottom-Up Design. Software Measurement and Metrics: Various Size Oriented Measures: Halestead's Software Science, Function Point (FP) Based Measures, Cyclomatic Complexity Measures: Control Flow Graphs.

Hours- **10**

Module-4

Software Testing: Testing Objectives, Unit Testing, Integration Testing, Acceptance Testing, Regression Testing, Testing for Functionality and Testing for Performance, Top-Down and Bottom-Up Testing Strategies: Test Drivers and Test Stubs, Structural Testing (White Box Testing), Functional Testing (Black Box Testing), Test Data Suit Preparation, Alpha and Beta Testing of Products. Static Testing Strategies: Formal Technical Reviews (Peer Reviews), Walk Through, Code Inspection, Compliance with Design and Coding Standards.

Hours- **10**

Module-5

Software Maintenance and Software Project Management Software as an Evolutionary Entity, Need for Maintenance, Categories of Maintenance: Preventive, Corrective and Perfective Maintenance, Cost of Maintenance, Software Re-Engineering, Reverse Engineering. Software Configuration Management Activities, Change Control Process, Software Version Control, An Overview of CASE

Tools. Estimation of Various Parameters such as Cost, Efforts, Schedule/Duration, Constructive Cost Models (COCOMO), Resource Allocation Models, Software Risk Analysis and Management.

Hours- **10**

Course Outcomes:

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

- **CO-1:** Identify the need for engineering approach to software development and various processes of requirements analysis for software engineering problems.
- **CO-2:** Analyze various software engineering models and apply methods for design and development of software projects.
- **CO-3:** Work with various techniques, metrics and strategies for Testing software projects.
- **CO-4:** Identify and apply the principles, processes and main knowledge areas for Software Project Management
- **CO-5:** Proficiently apply standards, CASE tools and techniques for engineering software projects

Course Outcome No	Statement	Knowledge Level (K)
CO1	Identify the need for engineering approach to software development and various processes of requirements analysis for software engineering problems.	K1
CO2	Analyze various software engineering models and apply methods for design and development of software projects.	K3
CO3	Work with various techniques, metrics and strategies for Testing software projects.	K6
CO4	Identify and apply the principles, processes and main knowledge areas for Software Project Management	K2
CO5	Proficiently apply standards, CASE tools and techniques for engineering software projects	K3

KL – Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1- Remember, K_2 – Understand, K_3 – Apply, K_4 – Analyze, K_5- Evaluate, K_6 – Create

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3			3				2	1			
CO2	2				1		1	3	3			
CO3	3		2	3				1	1			
CO4												
CO Average	2.66		2	3	1		1	2	1.66			

3 - High; 2 - Medium; 1 – Low

Text books:

1. R. S. Pressman, Software Engineering: A Practitioners Approach, McGraw Hill.
2. Rajib Mall, Fundamentals of Software Engineering, PHI Publication.
3. K. K. Aggarwal and Yogesh Singh, Software Engineering, New Age International Publishers.

4. Pankaj Jalote, Software Engineering, Wiley 5.Deepak Jain,"Software Engineering:Principles and Practices", Oxford University Press.

Engineering Chemistry (BT207L)

List of experiment

1. To determine the surface tension of a given sample liquid at room temperature using stalagmometer by drop number method.
2. Determination of the viscosity of the given sample liquid.
3. Determination of hardness of water by EDTA method.
4. Estimation of Fe2+ in Mohr's salt using permanganometry.
5. Qualitative analysis of given salt – 1.
6. Qualitative analysis of given salt – 2.
7. Synthesis of Bakelite.
8. To determine the electrochemical equivalence (E.C.E.) of Cu with the help of CuSO4 and Cu-electrode.
9. Determination of chloride concentration in a sample of water.
10. Determination of flash and fire points in lubricating oil using pensky-marten's closed-cup apparatus.

ENGINEERING MATHEMATICS – III

II Year B.Tech. 3rd -Sem

Course objectives:

This course will enable students to

1. Comprehend and use of analytical and numerical methods in different engineering fields
2. Apprehend and apply Fourier Series
3. Realize and use of Fourier transforms and Z-Transforms
4. Use of statistical methods in curve fitting applications
5. Use of numerical methods to solve algebraic and transcendental equations, vector integration and calculus of variation

Module – I

VECTOR DIFFERENTIATION

Scalar and vector point functions – Del applied to scalar point functions – Directionalderivative – Del applied to vector point functions – Physical interpretation of divergence and curl – Del applied twice to point functions – Del applied to products of point functions. Hours-10

Module – II

VECTOR INTEGRATION

Integration of vectors – Line integral, circulation, work done – Surface integral, flux – Green's theorem in the plane – Stoke's theorem – Volume integral – Gauss divergence theorem (all theorems without proofs) – Irrotational and solenoidal fields. Hours-10

Module – III

PARTIAL DIFFERENTIAL EQUATIONS AND THEIR APPLICATIONS

Introduction – Formation of partial differential equations by eliminating arbitrary constants and functions – Solutions of a partial differential equations by direct Integration – Linear equations of the first order (Lagrange's linear equations). Applications: Method of separation of variables – Vibrations of a stretched string: Wave equation – One dimensional heat flow equation (∂u/∂t=c^(2) (∂^2 u)/(∂x^2)), and two dimensional heat flow equation (i.e. Laplace equation : (∂^2 u)/(∂x^2)+(∂^2 u)/(∂y^2)=0). Hours-15

Module – IV

FOURIER SERIES

Introduction – Euler's formulae – Conditions for a Fourier expansion – Functions having points of discontinuity – Change of interval – Even and odd functions – Half range series – Parseval's formula. Hours-10

Module – V

FOURIER TRANSFORMS

Introduction – Definition – Fourier integral theorem (without proof) - Fourier sine and cosine integrals – Fourier transforms – Properties of Fourier transforms – Convolution theorem – Parseval's identity for Fourier transforms – Relation between Fourier and Laplace transforms Module – V Module – IV Module – I Module – II Module – III – Fourier transforms of the derivatives of a function – Applications of transforms to boundary value problems.

Hours-15

Course Outcomes:

At the end of this course, the students will be able:

- **CO-1:** To visualize and conceptualize the engineering problems.
- **CO-2:** To model the engineering problem mathematically using theory of calculus and matrices.
- **CO-3:** To determine the solution of the studied engineering problem from application point of view.
- **CO-4:** To validate the solution.
- **CO-5:** To implement the solution for engineering problem.

Course Outcome	Statement	Knowledge Level (K)

No		
CO1	To visualize and conceptualize the engineering problems.	K1
CO2	To model the engineering problem mathematically using theory of calculus and matrices.	K3
CO3	To determine the solution of the studied engineering problem from application point of view.	K6
CO4	To validate the solution.	K2
CO5	To implement the solution for engineering problem.	K3

KL – Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1- Remember, K_2 – Understand, K_3 – Apply, K_4 – Analyze, K_5- Evaluate, K_6 – Create

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3			3				2	1			
CO2	2				1		1	3	3			
CO3	3		2	3				1	1			
CO4												
CO Average	2.66		2	3	1		1	2	1.66			

3 - High; 2 - Medium; 1 – Low

Test Books:

1. Peter V. O'Neil, Advance Engineering Mathematics Thomson (Cengage) Learning, 2007.
2. Jain, Iyenger & Jain, Numerical Methods for Scientific and Engineering Computation, New Age International, New Delhi.
3. JN Kapur, Mathematical Statistics, S. Chand & company Ltd.
4. BS Grewal, Higher Engineering Mathematics, Khanna Publishers.

MINERAL PROCESSING

II Year B.Tech. 3rd -Sem

Course Objectives:

1. Introduce students to the principles of ore comminution, liberation and particle size analysisand the different equipment used in the processes.
2. Teach the students about various methods of concentration/ separation and the processessuitable to the liberated ore and equipment used.
3. Acquaint the students about quantifying concentration processes and selection of propermineral dressing cycles for an ore/mineral.

Module–1

Scope, objectives and advantages of ore dressing. Sampling of ores by different methods. Theory of liberation of minerals. Crushers**:** Jaw, Gyratory, Cone, Roll crushers. Types of grinding operations- batch and continuous, dry and wet grinding and open circuit and closed circuit grinding. Grinding Mills**:** Ball mills, theory of ball mill operation and rod mill. Comminution laws:- Rittinger's laws, Kick's law and Bond's law.

Module–2

Sizing Techniques: Laboratory and industry practices- Study of laboratory sizing techniques and reporting of sizing data. Types of screens, Movement of solids in fluids: Stokes and Newton's laws. Terminal velocity and its relation with size. Relation between time and velocity. Relation between distance traveled and velocity. Equal settling ratio, Free and hindered settling ratio. Quantifying concentrating operations: Ratio of concentration, recovery, selectivity index and economic recovery.

Module–3

Classification and types of classifiers**:** Study of settling cones, rake classifier, spiral classifier and cyclones. Heavy media separation: Principles, flow chart, different media used. Heavy media separation using heavy liquids and heavy suspensions. Jigging: Theory of jigging and Jigging machines**:** Harz, Baum, Denver jig.

Module -4

Tabling- Basic principle, study of stratification on a table, Wilfred Table. Basic principles of Magnetic separation processes and electrostatic separation process. Brief description about the working of belt and drum magnetic separator, high tension separator.

Module –5

Floatation: Principles of floatation. Factors affecting floatation. Classification of collectors and frothers. Regulators, factors affecting their efficiency. Floatation machines: Pneumatic and mechanical floatation cells.

Course Outcomes:

At the end of this course, the students will be able to:

- **CO-1:** understand the fundamental principles and unit operations of mineral processing,
- **CO-2:** design and analyze basic mineral processing circuits
- **CO-3:** apply their knowledge to solve practical problems in the field

Course Outcome No	Statement	Knowledge Level (K)
CO1	1. Recognise of the need of the mineral dressing prior to extraction of metals.	K1

CO2	Describe the working and construction details of various equipments used in mineraldressing.	K3
CO3	Assess the efficiency of concentration processes.	K6
CO4	Select and describe a particular concentration process suitable to the liberated ore.	
CO5	To make a logical link between mineral processing and economics of metal production.	
CO6	Apply the knowledge learned so as to being capable of understanding advance courses inmineral processing operations and modeling.	

KL – Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1- Remember, K_2 – Understand, K_3 – Apply, K_4 – Analyze, K_5- Evaluate, K_6 – Create

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3			3				2	1			
CO2	2				1		1	3	3			
CO3	3		2	3				1	1			
CO4												
CO5												
CO6												
CO Average	2.66		2	3	1		1	2	1.66			

3 - High; 2 - Medium; 1 – Low

Text Books:

1. Mineral Processing Technology - Barry A. Wills, James Finch Published by Butterworth-Heinemann, 2015.
2. Principles of Mineral Dressing - A.M. Gaudin, published by McGraw-Hill Inc., US, 1939.

References Books:

1. Text book of Mineral processing by D.V. Subba Rao, Scientific Publishers, 2007.
2. Ore dressing practices - S. K. Jain, Rotterdam: A.A. Balkema, 1987.
3. Elements of Ore Dressing by A.F. Taggart, John Wiley & Sons,1st Edition ,1951.

NON- FERROUS PROCESS METALLURGY

II Year B.Tech. 3rd -Sem

Course Objectives:

1. Understanding the Fundamentals of Non-Ferrous Metallurgy

2. Mastering the Principles of Mineral Benefication and Extraction
3. Gaining Expertise in Non-Ferrous Alloy Production and Processing
4. Understanding the Structure and Properties of Non-Ferrous Metals and Alloys
5. Applying Metallurgical Principles to Problem Solving and Material Selection

Module -1

Sources of nonferrous metals (Sources in land and sea, exploration methods, methods of beneficiation, nonferrous metals wealth in India), Principles of metals extraction, (Thermodynamic principles, homogeneous and heterogeneous reactions, Ellingham diagrams, kinetic principles, electro-chemistry).

Module -2

General methods of extraction, (Pyro-metallurgy – calcinations, roasting (predominance area diagram) and smelting, Hydrometallurgy – leaching, solvent extraction, ion exchange, precipitation, and electrometallurgy – electrolysis and electro-refining)

Module -3

General methods of refining, (Basic approaches, preparation of pure compounds, purification of crude metal produced in bulk), Extraction of metals from oxide sources, (Basic approaches and special features of specific extraction processes, extraction of metals such as Mg, Al, Sn),

Module -4

Extraction of metals from sulphide ores, (Pyro-metallurgy and hydro-metallurgy of sulphides, production of metals such as copper, lead, zinc, nickel etc.), Extraction of metals from halides, (Production of halides and refining methods, production of reactive and reactor metals. Methods of extraction of metals such as Ti, Ur)

Module -5

Production of precious metals (Methods applied for gold, silver and Pt.),

Course Outcomes:

At the end of this course, the students will be able to:

- **CO-1:** understanding the extraction and purification of non-ferrous metals
- **CO-2:** knowledge of different processing techniques for various non-ferrous metals and alloys
- **CO-3:** understanding the properties and applications of different non-ferrous materials
- **CO-4:** ability to apply metallurgical principles to solve problems in the non-ferrous metals industry.

Course Outcome No	Statement	Knowledge Level (K)
CO1	understanding the extraction and purification of non-ferrous metals	K1
CO2	knowledge of different processing techniques for various non-ferrous metals and alloys	K3
CO3	understanding the properties and applications of different non-ferrous	K6

	materials	
CO4	ability to apply metallurgical principles to solve problems in the non-ferrous metals industry.	

KL – Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1- Remember, K_2 – Understand, K_3 – Apply, K_4 – Analyze, K_5- Evaluate, K_6 – Create

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3			3				2	1			
CO2	2				1		1	3	3			
CO3	3		2	3				1	1			
CO4												
CO Average	2.66		2	3	1		1	2	1.66			

3 - High; 2 - Medium; 1 – Low

TEXT BOOKS:

1. Extraction of nonferrous metals, H.S. Ray, R.Sridhar and K.P. Abraham Affiliated East West Press Pvt Ltd., New Delhi (2007).
2. H.S. Ray and A. Ghosh, Principles of extractive metallurgy,Wiley Eastern Ltd., New Delhi (1991)

REFERENCE BOOKS:

1. W.H. Dennis, Extractive Metallurgy, Philosophical Library,New York (1965)
2. F. Habashi, Principles of Extractive Metallurgy, Vol.1, Gordon and Breach, New York (1969).
3. T. Rosenqvist, Principles of Extractive Metallurgy, McGraw Hill, New York (1983).
4. J.L. Bray, Nonferrous production metallurgy, Wiley, NewYork(1954).

METALLURGICAL THERMODYNAMICS –I

II Year B.Tech. 3rd -Sem

Course Objectives:

1. The prime aim of this course is to apply thermodynamics and kinetics to various metallurgical aspects like Solutions, Phase diagrams and Ellingham Diagrams.
2. The course is also intended to correlate electrochemical principles with thermodynamics.
3. To provide a consistent picture of thermodynamic concepts when applied to various topics

Module-1

Objectives and limitations to thermodynamics, concepts of system and state, heterogeneous and homogeneous systems, extensive and intensive properties of system, thermodynamic variables,

thermodynamic equilibrium and Zeroth law of thermodynamics. Reversible and irreversible processes.

Module-2

First Law of thermodynamics: Relationship between heat and work, internal energy and the first law of thermodynamics, calculations of work, Heat capacity, reversible adiabatic processes, reversible isothermal pressure or volume changes, of an ideal gas, Joules experiment, Joule- Thompson experiment, Joule-Thompson co-efficient, Enthalpy change with temperature, Kirchhoff's equation. Efficiency of a cyclic process, Carnot cycle, Carnot theorem, Second law of thermodynamics, concept of entropy, Quantification of irreversibility.

Module-3

Free energy functions: Purposes of the new functions, definition of Helmholtz and Gibbs free energy change, meaning of thermodynamically possible process, determination of ΔG from thermal data, useful relationships between free energies and other thermodynamic functions, Maxwell's equations and Gibbs-Helmholtz equation.

Module-4

Third law of thermodynamics: Background of third law, deductions from third law, applications of third law, other methods of obtaining ΔS^0 for a reaction

Fugacity, activity and equilibrium constant: Concepts of fugacity, activity and equilibrium constant variation of the equilibrium constant with temperature, sigma functions.

Module-5

Claussius – Clapeyron equation: Introduction, derivation of the Claussius – Clapeyron equation for single substance, Troutons Rule and Ramsay Young Rule, Duhring rule for the estimation of the vapour pressures of an element, Integration of Claussius – Clapeyron equation.

Course Outcomes:

At the end of this course, the students will be able to:

- **CO-1:** understanding and applying fundamental thermodynamic concepts and laws
- **CO-2:** utilizing thermodynamic relations to predict and solve problems in metallurgical processes
- **CO-3:** grasping the concept of energy, entropy, and their applications in materials science
- **CO-4:** interpreting and applying Ellingham diagrams for oxide formation and reduction

Course Outcome No	Statement	Knowledge Level (K)
CO1	understanding and applying fundamental thermodynamic concepts and laws	K1
CO2	utilizing thermodynamic relations to predict and solve problems in	K3

	metallurgical processes	
CO3	grasping the concept of energy, entropy, and their applications in materials science	K6
CO4	interpreting and applying Ellingham diagrams for oxide formation and reduction	K4

KL – Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1- Remember, K_2 – Understand, K_3 – Apply, K_4 – Analyze, K_5- Evaluate, K_6 – Create

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3			3				2	1			
CO2	2				1		1	3	3			
CO3	3		2	3				1	1			
CO4												
CO Average	2.66		2	3	1		1	2	1.66			

3 - High; 2 - Medium; 1 – Low

Text Books:

1. Introduction to Metallurgical Thermodynamics – D.R. Gaskell, hemisphere Publishing Corporation, 1981.
2. Chemical and Metallurgical Thermodynamics (Vol I &II) - M.L. Kapoor, Nemchand & Bros Publishers, 1984.

Reference Books:

1. Physical chemistry for Metallurgists – J. Mackowiak, Allen & Unwin, 2nd edition, 1967.
2. Thermodynamics of solids- R.S. Swalin, John Wiley Publisher, 1972.
3. Physical chemistry of metals- L.S. Darken & Gurry, CBS publishers & Distributors 2002.
4. Problems in Metallurgical Thermodynamics: G.S Upadhyaya, R.K. Dubey, Elsevier Science, 2013.

Course Outcomes:

At the end of the course the student would be able to:

1. Knowledge of the type of variable that affects heterogeneous reaction rates nucleation, interfacial energy, interface equilibrium and diffusion.
2. Relate 1st and 2nd Law of thermodynamics.
3. Knowledge of enthalpy, entropy and free energy.
4. Understand the principles of kinetics and thermodynamics as applied to rates and equilibrium positions of chemical reactions.
5. Calculate the temperature dependence of rate constants and relate this calculation to activity and fugacity.

PHYSICAL METALLURGY

II Year B.Tech. 3rd -Sem

Course Objectives:

1. Give basic concepts of material science.
2. The prime objective of this course is to make the student gain an understanding of the relation between microstructural characteristics and properties of metals and alloys.
3. The course also critically focuses on the crystallography, phase transformations that occur in several ferrous and nonferrous metallurgical systems as a function of temperature and composition through phase equilibrium diagrams.

Module –1

Structure of Metals, Types of chemical bonding, crystal systems, plane and directional indices, transformation of indices, coordination number, relationship between lattice parameter and atomic radius, packing factor and density calculations, interstitial voids.

Module –2

Diffusion: Fick's laws of diffusion and its applications, Kirkendall effect, Darken's equations, the Matano Method. Determination of intrinsic diffusivities, self diffusion in pure metals, Temperature dependence of the diffusion coefficient, diffusion along the grain boundaries and surfaces.

Module–3

Types of nucleation, determination of the size of critical nucleus, equilibrium cooling and heating of alloys.

Constitution of Alloys: Necessity of alloying, types of solid solutions, Hume-Rothery's rules. Intermediate alloy phases, electron-chemical compounds and electron phases.

Equilibrium Diagrams: Construction, lever rule, phase rule.

Module–4

Types of Phase diagrams: Binary Isomorphous alloy systems, non- equilibrium cooling. Binary eutectic system, peritectic and monotectic reactions, miscibility gaps. Phase diagrams with intermediate phases and compounds Transformation in solid state: allotropy, eutectoid, peritectoid reactions and order-disorder transformations.

Module-5

Study of Fe-Fe_3 C phase diagram. Study of other important binary phase diagrams: Al-Cu, Cu-Zn, Cu-Sn, Pb-Sn, and complex phase diagrams. Strengthening mechanisms: strengthening of grain boundary, work hardening, solid solution strengthening, precipitation hardening and dispersion strengthening.

Course Outcomes:

At the end of this course, the students will be able to:

- **CO-1:** Analyze the structure of crystalline materials and calculate the various crystals parameters.
- **CO-2:** Explain the working of metallurgical microscope and its different parts.
- **CO-3:** Explain the necessity of alloys, will identify the different types of alloy phases.
- **CO-4:** Explain the construction and identification of phase diagrams and reactions.
- **CO-5:** Explain the Fe-Fe_3C diagram with invariant reactions.
- **CO-6:** Explain the Cu-Zn and other binary diagrams and complex phase diagrams etc.

Course Outcome No	Statement	Knowledge Level (K)
CO1	Analyze the structure of crystalline materials and calculate the various crystals parameters.	K1
CO2	Explain the working of metallurgical microscope and its different parts.	K3
CO3	Explain the necessity of alloys, will identify the different types of alloy phases.	K6
CO4	Explain the construction and identification of phase diagrams and reactions.	K4
CO5	Explain the Fe-Fe_3C diagram with invariant reactions.	K3
CO6	Explain the Cu-Zn and other binary diagrams and complex phase diagrams etc.	K4

KL – Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1- Remember, K_2 – Understand, K_3 – Apply, K_4 – Analyze, K_5- Evaluate, K_6 – Create

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3			3				2	1			
CO2	2				1		1	3	3			
CO3	3		2	3				1	1			
CO4												
CO5												
CO6												
CO Average	2.66		2	3	1		1	2	1.66			

3 - High; 2 - Medium; 1 – Low

Text Books:

1. Materials Science and Engineering, An introduction. WD Callister, Jr., Adapted by

R. Balasubramaniam, John Wiley & Sons, NY, Indian edition, 2007.
2. Introduction to Physical Metallurgy – SH Avner, TATA Mc GRAW HILL,1997.

Reference Books:

1. Physical Metallurgy Principles- R.E. Reed Hill, Affiliated East-West Press, 2008.
2. Physical Metallurgy - V. Raghavan, PHI Learning; 3rd edition, 2015.
3. Physical Metallurgy - Vijendra Singh, Standard Publishers Distributors, 2020.
4. Foundations of Materials Science and Engineering – WF Smith McGraw-Hill Education, 5th edition 2009.
5. Metallurgy for Engineers- Clark and Varney, Van Nostrand Reinhold Company, 2nd Revised edition, 1962.

Course Outcomes:

At the end of the course the student will be able to:

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MATERIALS CHARACTERIZATION TECHNIQUES

II Year B.Tech. 3rd -Sem

Course Objectives:

1. To explain and describe the various working techniques of optical microscope, Scanningand Transmission Microscopes used for evaluating material properties.
2. To explain and describe the various working techniques of XRD, SPM, AFM for evaluatingmaterial properties.
3. To differentiate and compare between various characterization techniques.
4. Obtain knowledge on the various thermal analyses techniques.

Module -1

Optical Microscopy–Introduction, optical principles, Instrumentation, specimen preparation-metallographic principles, Imaging Modes, Applications, Limitations.

Module -2

(a) Scanning Electron Microscopy (SEM) - Introduction, instrumentation, Contrast formation, Operational variables, Specimen Preparation, Imaging Modes, Applications, and Limitations.
(b) Transmission Electron Microscopy (TEM**)** - Introduction, instrumentation, Specimen preparation –pre thinning, final thinning, Image modes-mass density contrast, diffraction contrast, Phase contrast, Applications, Limitations.

Module -3

X-Ray Diffraction (XRD) - Introduction, production and properties of X-ray, Absorption and diffraction, Instrumentation, determination of Structure, Crystallite size, phase diagram and residual stresses.

Module -4

Thermal Analysis: Introduction, Differential thermal analysis, Differential Scanning Calorimetry, Thermogravimetry, Dilatometry, Dynamic Mechanical analysis.

Module -5

Scanning Probe Microscopy (SPM), Scanning Tunneling Microscopy-Basics, Probe Tips, Working environment, operational modes, Applications, Limitations.
Atomic Force Microscopy (AFM) – Basic Principles, instrumentation, operational modes, Applications, Limitations.

Course Outcomes:

At the end of this course, the students will be able to:

- **CO-1:** Able to use metallurgical microscopes to analyze the experimental results.
- **CO-2:** Understand the various specimen preparation techniques for SEM, TEM and analyze theexperimental results.
- **CO-3:** Describe the construction of XRD machine and understand its principle and analyze /interpret the experimental results.
- **CO-4:** Conduct characterization measurement by thermal analysis and solve problem using thethermo dynamic principles.
- **CO-5:** Knowledge on thermal analyses methods such as DSC, calorimetry and dilatometry etc.,
- **CO-6:** Analyze, evaluate and interpret data and solve practical characterization problems usingmodern tools like SPM, AFM etc
- **CO-7:** Able to use metallurgical microscopes to analyze the experimental results.

Course Outcome No	Statement	Knowledge Level (K)
CO1	Able to use metallurgical microscopes to analyze the experimental results.	K1
CO2	Understand the various specimen preparation techniques for SEM, TEM and analyze theexperimental results.	K3
CO3	Describe the construction of XRD machine and understand its principle and analyze /interpret the experimental results.	K6
CO4	Conduct characterization measurement by thermal analysis and solve problem using thermodynamic principles.	K4
CO5	Knowledge on thermal analyses methods such as DSC, calorimetry and dilatometry etc.,	K2
CO6	Analyze, evaluate and interpret data and solve practical characterization problems usingmodern tools like SPM, AFM etc.	K4
CO7	Able to use metallurgical microscopes to analyze the experimental results.	K3

KL – Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1- Remember, K_2 – Understand, K_3 – Apply, K_4 – Analyze, K_5- Evaluate, K_6 – Create

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3			3				2	1			
CO2	2				1		1	3	3			
CO3	3		2	3				1	1			
CO4												
CO5												
CO6												
CO7												
CO Average	2.66		2	3	1		1	2	1.66			

3 - High; 2 - Medium; 1 – Low

Text Books:

1. Experimental Techniques in Physical Metallurgy, V.T. Cherepin and A.K. Mallik, Asia Publishing House, 1967.
2. Thermal Analysis of Materials - Robert F. Speyer, published by Marcel Dekker, Inc. New York, 1994.

Reference Books:

1. Electron Microprobe Analysis - S.J.B. Reed, Cambridge University Press, 1975.
2. Materials Characterization, ASM Hand book, vol -10, ASM International, 2019.

PHYSICAL METALLURGY LAB

II Year B.Tech. 3rd -Sem

Course Objectives:

The laboratory course helps to:

1. Gain skills of preparation of samples for metallographic examinations.
2. Find and analyze the microstructures of various ferrous and non ferrous materials.
3. Use the suitable metallurgical microscope with suitable magnification.

List of Experiments:

1. Preparation and study of Crystal models.
2. Study of various microscopes (Optical microscope, SEM, TEM) and specimen preparation techniques for metallurgical microscope.
3. Metallographic preparation and microstructure evaluation of low carbon steel.
4. Metallographic preparation and microstructure evaluation of medium carbon steel.
5. Metallographic preparation and microstructure evaluation of high carbon steel.
6. Metallographic preparation and microstructure evaluation of different cast irons (grey cast iron, white cast iron, malleable cast iron, spheroidal graphite iron).
7. Metallographic preparation and microstructure evaluation of Copper.
8. Metallographic preparation and microstructure evaluation of Brass.

9. Determination of phase fraction and grain size using Image analyzer.
10. Drawing of the Binary phase diagrams of Isomorphous (Cu-Ni), Eutectic (Pb-Sn, Al-Si) and partial solubility diagram (Al-Cu) with interpretation.
11. Drawing of complex binary phase diagrams (Al_2O_3-SiO_2, MgO-Al_2O_3) and identification of points, lines and areas in them.
12. Experiments to obtain cooling curves for pure metals and alloys and to establish binary phase diagram.

Course Outcomes:

By completing this laboratory course, students:

1. Can describe the metallurgical microscope, sample preparation, mounting and use/choosing of different etching reagents.
2. Can identify and report the microstructural features of ferrous and non ferrous samples observed.
3. Can operate optical microscope with an ease.
4. Characterize microstructures of engineering alloys using optical microscopy and image analyzer.
5. Prepare formal laboratory reports.

MINERAL PROCESSING LAB

II Year B.Tech. 3rd Sem

Pre- Requisites: Mineral Dressing

Course Objectives:

This laboratory course is designed to

1. To teach the student how to conduct sampling and sieve analysis.
2. Make the student to learn and demonstrate the usage of crushers and grinders.
3. Learn to conduct concentration methods at laboratory scale.
4. Teach the students how to note down the observations and results obtained in the experiments.

List of Experiments:

1. Sampling of an ore from the bulk by
   (i) Coning and quartering method.
   (ii) Riffle sampler.
2. Determination of average particle size of a given material by sieve analysis.
3. Verification of Stoke's Law.
4. Size reduction of the given material using Jaw Crusher and determining the reduction ratio.
5. Size reduction of the given material using Roll Crusher and determining the reduction ratio.
6. Size reduction of the given material using Ball Mill and determining the reduction ratio.
7. Determine the grindability index of coal using hard groove grindability machine.
8. Separation of the given material into magnetic and non magnetic particles using magnetic separator.

9. Determination of recovery percentage of the concentrate by Froth- Floatation process.
10. Study of a jigging machine.

Course Outcomes:

At the end of the laboratory course the student will be able to:

1. Pick or take a representative amount of sample and conduct experiments / tests.
2. Determine the reduction ratio in crushing and grinding of different materials using various types of size reduction units.
3. Analyze the grindability of different coals.
4. Separate or concentrate the given materials using magnetic separation and froth flotation processes.
5. Prepare formal laboratory reports.

CERAMICS AND COMPOSITE MATERIALS

III Year B.Tech. 4th -Sem

Course Objectives:

1. Develop understanding of the structure of ceramic materials on multiple length scales.
2. Develop knowledge of point defect generation in ceramic materials, and their impact ontransport properties.
3. To describe key processing techniques for producing metal, ceramic and polymer-matrixcomposites.
4. To demonstrate the relationship among synthesis, processing, and properties in compositematerials

Module -1

Introduction – classification of ceramics – imperfections in ceramics – structure of ceramics – crystal structures – oxide structures – silicate structures – glass formation – types of glasses.

Module -2

Ceramic Phase diagrams: Study of binary phase diagrams like MgO-NiO; CaO-MgO;MgO-Al_2O_3, Al_2O_3 - SiO_2.

Module -3

Introduction to Composite materials, Fibers: Fabrication, structures, properties and applications of glass fibers, boron fibers, carbon fibers, organic fibers, ceramic fibers and metallic fibers.

Matrix materials: Polymers, metals and ceramic matrix materials.

Module -4

Manufacturing of composites: polymer matrix composites, metal matrix composites, ceramic matrix composites, carbon fiber composites.

Module -5

Interfaces and bonding, strengthening and toughening mechanism, Testing of interfacial strength.

Text Books:

1. Introduction to Ceramics by William David Kingery, John Wiley and Sons Ltd. publishers, 1976.
2. Composite Materials-science and Engineering, 2nd edition - Krishan K. Chawla, Springer (Sie) publishers, 2006.

Reference Books:

1. Engineering Materials and their applications, 4th edition - Richard A. Flinn, Paul K. Trojan, Wiley publishers, 1990.
2. Hand book of Fibre – reinforced composite materials – George Lubin, Springer publishers, 1982.

Course Outcomes:

At the end of this course, the students will be able to:

- **CO-1:** Identify and explain the types of ceramic materials and their applications.
- **CO-2:** Illustrate and interpret the ceramic phase diagrams.
- **CO-3:** Identify and explain the types of composite materials and their characteristic features
- **CO-4:** Predict and list out the properties matrix and reinforcement materials
- **CO-5:** Describe fundamental fabrication processes for polymer matrix, metal matrix, and ceramicmatrix composites.
- **CO-6:** Able to undertake any technical assignment in R&D and production of newer and smartermaterials.

Course Outcome No	Statement	Knowledge Level (KL)
CO1	Identify and explain the types of ceramic materials and their applications.	K1
CO2	Illustrate and interpret the ceramic phase diagrams.	K3
CO3	Identify and explain the types of composite materials and their characteristic features	K6
CO4	Predict and list out the properties matrix and reinforcement materials	K4
CO5	Describe fundamental fabrication processes for polymer matrix, metal matrix, and ceramicmatrix composites.	K2
CO6	Able to undertake any technical assignment in R&D and production of newer and smartermaterials.	K4

KL – Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1- Remember, K_2 – Understand, K_3 – Apply, K_4 – Analyze, K_5- Evaluate, K_6 – Create

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3			3				2	1			
CO2	2				1		1	3	3			
CO3	3		2	3				1	1			
CO4												
CO5												
CO6												
CO7												

CO Average	2.66		2	3	1		1	2	1.66			

3 - High; 2 - Medium; 1 – Low

METALLURGICAL THERMODYNAMICS-II

II Year B.Tech. 4th -Sem

Course Objectives:

This course is mainly intended to deals with

1. Interpret Ellingham diagrams
2. Identify metallurgical thermodynamics principles to be applied in phase diagrams.
3. Identify metallurgical thermodynamics principles to be applied in reversible cells

Module -1

Ellingham Diagrams: Introduction, calculation of equilibrium constants from standard free energy changes, general description of Ellingham diagrams, Interpretation of free energy changes Vs. temperature lines, Richardson's diagrams.

Module -2

Solutions: Solution definition, Composition, partial molal quantities, ideal solutions, Raoult's Law, actual (Nonideal) solutions, Sievert's law, Gibbs - Duhem equation, integration of Gibbs - Duhem equation, Excess thermodynamics quantities.

Module -3

Application to phase diagrams: Concept of chemical potential, equality of chemical potentials in equilibrated phases, Derivation of Gibbs phase rule, solidus and liquidus lines for an ideal solution, calculation of liquidus line for eutectic systems.

Module -4

Reversible Cells: Electro- Chemical cells, galvanic cells, chemical and electrical energy, thermodynamics of Electro-chemical cells, standard electrode potentials, sign convention of electrode potentials, application of Gibbs - Helmholtz equation to galvanic cells. Concentration Cells.

Module -5

Kinetics: Kinetics of chemical process, Molecularity and order of a reaction, zero order reactions, first order, second order reactions, Determination of order of reaction, collision theory, theory of absolute reaction rates, consecutives and simultaneous reactions, catalysis in chemical reactions.

Text Books:

1. Physical Chemistry for Metallurgist by J. Mackowick, Allen and Unwin publisher, 1966.
2. Physical Chemistry of Metals by LS Darken and Gurry, CBS publisher and Distributor, 2002.

Reference Books:

1. Thermodynamics of solids by RA Swalin, Wiley VCH; 2nd edition, 1973.
2. Essentials of Metallurgical Thermodynamics – R.H. Tupkary, Khanna Book Publishing Co. (P) Ltd. 2016.
3. Principles of Metallurgical Thermodynamics: Subir Kumar Bose, Sanat Kumar Roy, Universities Press, 2014.

Course Outcomes:

At the end of this course, the students will be able to:

- **CO-1:** Interpret Ellingham Diagram for oxides.
- **CO-2:** Knowledge of ideal and regular solutions and free energy of mixing.
- **CO-3:** Apply the phase rule on the metallurgical systems.
- **CO-4:** Understanding of the nature of polarized electrochemical reactions and an introduction oftheir application in corrosion behavior of metals.
- **CO-5:** Determine order of reaction. Explain the central concepts of chemical kinetics. Formulateand solve rate equations for various reactions.

Course Outcome No	Statement	Knowledge Level (KL)
CO1	Interpret Ellingham Diagram for oxides.	K1
CO2	Knowledge of ideal and regular solutions and free energy of mixing.	K3
CO3	Apply the phase rule on the metallurgical systems.	K6
CO4	Understanding of the nature of polarized electrochemical reactions and an introduction of their application in corrosion behavior of metals.	K4
CO5	Determine order of reaction. Explain the central concepts of chemical kinetics. Formulateand solve rate equations for various reactions	K2

KL – Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1- Remember, K_2 – Understand, K_3 – Apply, K_4 – Analyze, K_5- Evaluate, K_6 – Create

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3			3				2	1			
CO2	2				1		1	3	3			
CO3	3		2	3				1	1			
CO4												
CO5												
CO6												
CO7												

CO Average	2.66		2	3	1		1	2	1.66			

3 - High; 2 - Medium; 1 – Low

PRINCIPLES OF EXTRACTIVE METALLURGY

II Year B.Tech. 4th -Sem

Pre-Requisites: Mineral Processing and Metallurgical Thermodynamics-I

Course Objectives:

1. To learn and emphasize the principles of pyro metallurgy, hydrometallurgy and electrometallurgy.
2. To learn scientific concepts of extraction and refining.
3. Obtain knowledge of equipment used in pyro metallurgy, hydrometallurgy and electrometallurgy.
4. Gain basic knowledge about palletization and Sintering

Module -1

Introduction: Classification of ores. Basics of Pyrometallurgy, Calcination, Roasting and types of roasting, Oxidising, sulphatising, and chloridizing. Roasting furnaces: Multiple hearth roaster, flash roasting, fluidized bed roasting and blast roasting.

Module -2

Pelletisation and Sintering, Smelting: Principles of reduction and matte smelting with examples. Smelting furnaces: Reverberatory, Blast Furnace and electric smelting. Flash smelting.
Slags: Classification, properties, Application of Ellingham diagrams for oxides and sulphides.

Module -3

Hydrometallurgy: Flowchart, Principles and types of leaching, Advantages and limitations, Solution purification by ion and solvent exchange methods, Metal recovery from leach solution by cementation.

Module -4

Classification of electrometallurgy, Principles of electrometallurgy, Advantages and limitations of electrometallurgy, Electro winning and Electro refining with typical examples.

Module -5

Principles of Refining: Fire refining, Distillation, liquation, electro-refining and zone refining with some examples.

Text Books:

1. Non-ferrous extractive metallurgy: H.S.Ray, K.P.Abraham and R.Sreedhar, Affiliated East West Private Limited, 2008.

2. Principles of extractive metallurgy - H.S. Ray & A. Ghosh, New - Age International Publisher, 3rd Edition, 2018.

Reference Books:

1. Extractive Metallurgy: Process and Applications: Sujay Kumar Dutta, Avinash B. Lele and Yakshil B. Chokshi, PHI Learning Pvt. Ltd., 2018.
2. A text book of metallurgy - A. R. Bailey, Macmillan & Co, 1st edition, 1960.
3. Principles of extractive metallurgy - Terkel Rosenqvist, Tapir Academic Press, 2004.

Course Outcomes:

At the end of the course the student will be able to:

- **CO-1:** Classify the different ores and describe the various units operating like pyro metallurgy, hydrometallurgy and electrometallurgy.
- **CO-2:** Differentiate the various types of slags, properties and their applications.
- **CO-3:** Illustrate with the help of flow sheet of process taking place in pyro metallurgy, hydrometallurgy and electrometallurgical extractions of metal/matte.
- **CO-4:** Choose the type of refining process according purity required.
- **CO-5:** Understand the impact of extractive process on health environment society and will be able to suggest suitable techniques to recycle the byproducts or to decrease energy consumptions.
- **CO-6:** Design the suitable process for extraction.

Course Outcome No	Statement	Knowledge Level (KL)
CO1	Classify the different ores and describe the various units operating like pyro metallurgy, hydrometallurgy and electrometallurgy.	K1
CO2	Differentiate the various types of slags, properties and their applications.	K3
CO3	Illustrate with the help of flow sheet of process taking place in pyro metallurgy, hydrometallurgy and electrometallurgical extractions of metal/matte.	K6
CO4	Choose the type of refining process according purity required.	K4
CO5	Understand the impact of extractive process on health environment society and will be able to suggest suitable techniques to recycle the byproducts or to decrease energy consumptions.	K2
CO6	Design the suitable process for extraction.	K3

KL – Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1- Remember, K_2 – Understand, K_3 – Apply, K_4 – Analyze, K_5- Evaluate, K_6 – Create

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3			3				2	1			
CO2	2				1		1	3	3			

CO3	3		2	3				1	1			
CO4												
CO5												
CO6												
CO Average	2.66		2	3	1		1	2	1.66			

3 - High; 2 - Medium; 1 – Low

FUELS, FURNACES & REFRACTORIES

II Year B.Tech. 4th -Sem

Course Objectives:

1. Relate the properties and applications of solid, liquid and gaseous fuels.
2. Broad knowledge on modes of heat transfer.
3. Describe the different types of refractories and pyrometers and their properties and uses.
4. Have a basic knowledge on working of different types of furnaces.

Module –1

Introduction to Fuels technology: Classification of fuels, Origin and classification of coal, Proximate and ultimate analysis of coal and its applications. Properties and uses of Pulverized coal, Carbonization of coal and types of Carbonization. Properties, uses and testing of Metallurgical Coke.

Liquid fuels: Properties and applications.

Module –2

Manufacture, properties and uses of Producer gas and Water gas.

Modes of heat transfer, Importance of heat transfer. Steady State Heat Transfer: Conduction through plane, cylindrical, Spherical and compound walls. Convection: Free and Forced conventions. Heat transfer by combined effect of conduction and convection between two fluids separated by a plane wall and cylindrical wall.

Module -3

Furnaces: Classification and uses of furnaces, characteristic features of Vertical Shaft furnaces, Reverberatory furnaces, Arc and Induction furnaces, Tube and Muffle type Resistance furnaces, Continuous furnaces. Heat losses in furnaces and heat balance.

Module -4

Pyrometry: Thermo electric pyrometer - Peltier and Thomson e.m.f. Thermo-electric power of thermocouples. Required properties of thermocouples. Noble and base metal thermocouples. Principle, operation and applications of Thermometer, Optical and Radiation pyrometers.

Module – 5

Refractories: Classification and desirable properties of refractories, modes of failure of refractories in service and their prevention. Manufacturing methods and properties of Fireclay, Silica, Magnesite, Dolomite, Chromite and Carbon refractories. Testing of Refractories, Applications of refractories in the metallurgical industries.

Text Books:

1. Fuels, Furnaces and Refractories – O.P. Gupta, 6th edition, Khanna Publishers, 1989.
2. Metallurgical furnaces – Krivadan and Markov, MIR publishers, 1980.

Reference Books:

1. Elements of fuel technology – HIMUS, TBS The Book Service Ltd; 2nd Revised edition 1958.
2. Furnaces - J. D. Gilchrist, Pergamon Pr; 2nd edition, 1977.
3. Pyrometry -W.P. wood & J. M. Corck.
4. Elements of heat transfer - Jakob & Hawikns, John Wiley & Sons, 3rd edition, 1957.
5. Elements of thermodynamics & heat transfer - Obert & Young, McGraw-Hill Inc., US, 3rd edition,1962.
6. Control systems & Instrumentation – S. Bhasker.

Course Outcomes:

At the end of the course the student will be able to:

- **CO-1:** Know about a fuel, classify them and compare different types of fuels and describe their testing methods. Explain the coke making process, list out the properties and its by-products recovery and suggest methods for decreasing environmental pollution and energy consumption.
- **CO-2:** Apply principles of heat and mass transfer to basic engineering systems and understand the basic concepts and laws of the three modes of heat transfer and apply analytical techniquesto the solution of conduction heat-transfer problems.
- **CO-3:** Classify and explain construction and working of different furnaces. Analyze the causes of heat losses in furnaces and suggest methods of minimization of heat loss and waste heat recovery.
- **CO-4:** Describe the operation of a thermocouple. Describe various temperature-measuring devices
- **CO-5:** thermometers and pyrometers. Discuss the principles that govern noncontact thermal measurements and describe the operation of optical and radiation pyrometers.
- **CO-6:** Explain various manufacturing and testing processes of refractories. Itemize many examples of metallurgical refractories under different categories, their main properties and applications. Link inherent properties of the refractory mineral and how it affects the production technology and the application.

Course Outcome No	Statement	Knowledge Level (KL)
CO1	Know about a fuel, classify them and compare different types of fuels and describe their testing methods. Explain the coke making process, list out the properties and its by-productsrecovery and suggest methods for decreasing environmental pollution and energy consumption.	K1
CO2	Apply principles of heat and mass transfer to basic engineering systems and understand thebasic concepts and laws of the three modes of heat transfer and apply analytical techniques to the solution of conduction heat-transfer problems.	K3
CO3	Classify and explain construction and working of different furnaces. Analyze the causes ofheat losses in furnaces and suggest methods of minimization of heat loss and waste heat recovery.	K6
CO4	Describe the operation of a thermocouple. Describe various temperature-measuring devices	K4
CO5	thermometers and pyrometers. Discuss the principles that govern noncontact thermal measurements and describe the operation of optical and radiation pyrometers.	K2
CO6	Explain various manufacturing and testing processes of refractories. Itemize many examples of metallurgical refractories under different categories, their main properties and applications. Link inherent properties of the refractory mineral and how it affects the production technology and the application.	K3

KL – Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1- Remember, K_2 – Understand, K_3 – Apply, K_4 – Analyze, K_5- Evaluate, K_6 – Create

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3			3				2	1			
CO2	2				1		1	3	3			
CO3	3		2	3				1	1			
CO4												
CO5												
CO6												
CO Average	2.66		2	3	1		1	2	1.66			

3 - High; 2 - Medium; 1 – Low

IRON MAKING

II Year B.Tech. 4th -Sem

Pre-requisites: Mineral Processing and Metallurgical Thermodynamics -I

Course Objectives:

1. Discuss the evolution of Iron making in chronological order.
2. Illustrate the applications of thermodynamics and kinetics in production of pig iron and refining it.
3. Outline the techniques for production and primary processing in Blast furnace.
4. Differentiate between past and present production methods and examine the modern trends in iron production.
5. Identify consists and effect for blast furnace irregularities and their remedial measures.

Module - 1

Raw materials for Iron making. Occurrence and distribution of iron ores. Classification and factors affecting valuation of iron ores. Preparation of iron ores.

Module – 2

Blast Furnace profile and design considerations. Furnace lining. Furnace cooling system. BF Stoves. BF gas cleaning system. Blast furnace operation and irregularities.

Module - 3

Systems of importance in iron making, blast furnace reactions. Thermodynamics of iron oxide reduction by $CO + CO_2$ and H_2 and H_2O mixtures. Control of C, Si, S, P in metals and slags.

Module - 4

Modern trends in blast furnace: High top pressure, humidification of blast, Oxygen enrichment, hot blast temperature and top charging systems.

Module - 5

Alternative routes of iron making: Sponge iron making: HYL and Rotary Kiln.
Smelting and reduction methods such as Corex process.

Course Outcomes: At the end of the course the student will be able to:

- **CO-1:** Describe the developments of Iron making and recognize the importance of processing raw materials for Iron making keeping in view of economics, safety and efficiency.
- **CO-2:** Identify the required parameters and design of a blast furnace and illustrate ancillary equipment and measures to be taken for starting and trouble shooting of Blast furnace process.
- **CO-3:** Predict the physico-chemical phenomena taking place in blast furnace. Able to perform simple mass balance and complex problems.
- **CO-4:** Identify and explain the modernization techniques to improve quantity, quality andminimization of waste.
- **CO-5:** Able to predict the possible alternative processes to be followed suitable to the local conditions in view of energy, environmental and efficiency considerations.
- **CO-6:** Able to undertake any technical assignment in R&D and production units with professionalresponsibility towards profession and society.

Course Outcome No	Statement	Knowledge Level (KL)
CO1	Describe the developments of Iron making and recognize the importance of processing raw materials for Iron making keeping in view of economics, safety and efficiency.	K1
CO2	Identify the required parameters and design of a blast furnace and illustrate ancillary equipment and measures to be taken for starting and trouble shooting of Blast furnace process.	K3
CO3	Predict the physico-chemical phenomena taking place in blast furnace. Able to perform simple mass balance and complex problems.	K6
CO4	Identify and explain the modernization techniques to improve quantity, quality andminimization of waste.	K4
CO5	Able to predict the possible alternative processes to be followed suitable to the local conditions in view of energy, environmental and efficiency considerations.	K2
CO6	Able to undertake any technical assignment in R&D and production units with professionalresponsibility towards profession and society.	K3

KL – Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1- Remember, K_2 – Understand, K_3 – Apply, K_4 – Analyze, K_5- Evaluate, K_6 – Create

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3			3				2	1			
CO2	2				1		1	3	3			
CO3	3		2	3				1	1			
CO4												
CO5												
CO6												
CO Average	2.66		2	3	1		1	2	1.66			

3 - High; 2 - Medium; 1 – Low

Text Books:

1. Iron making and steel making – Theory and practice Ahindra and Ghosh.
2. Hot metal production by smelting reduction of Iron ore - Amit Chatterjee, P & H publications, 2010.
3. An Introduction to Modern Iron Making - Dr. R.H. Tupkary, Khanna Publishers, 2004.

References Books:

1. Beyond the B.F – Amit Chatterjee.
2. Sponge Iron production by direct reduction of Iron ores - Amit Chatterjee, P & H, publications, 2010.

POWDER METALLURGY

II Year B.Tech. 4th -Sem

Course Objectives:

1. To build the necessary back ground of emergence and importance of powder metallurgy scope and limitations.
2. Obtain a necessary knowledge about various powder production techniques and characteristics.
3. Obtain a working knowledge of compaction and sintering techniques.
4. Gain an effective knowledge of applications of powder metallurgy products.

Module –1

Introduction: Emergence and importance of powder metallurgy**:** Comparison of powder metallurgy with other fabrication techniques, its scope and limitations. Powder Production Methods: Physical, Chemical and Mechanical.

Module –2

General Characterization of powders**:** Chemical composition, Particle size, Particle shape, Surface area, Apparent density, Tap density, Flow rate, Green density, Green strength, Compressibility and Compactability of powders.

Module –3

Compaction**:** Classification and theory of consolidation. Die compaction. Cold and hot isostatic pressing, Powder rolling or roll compaction.

Module –4

Sintering: Mechanisms of Sintering, Activated sintering, Liquid phase sintering, Factors affecting sintering, Sintering atmospheres, Properties of sintered parts.

Module –5

Applications**:** Porous parts**:** Self-lubricating bearings, filters: Dispersion strengthened alloys by powder metallurgy route**:** Cu / Al_2O_3, Sintered Aluminum Powder. Electrical materials**:** Tungsten lamp filaments. Magnetic materials**:** Soft magnetic materials (Fe, Fe-Ni); Permanent magnets (Alnico, $SmCo_5$), Cemented carbides and Cermets.

Course Outcomes:

At the end of the course the student will be able to:

- **CO-1:** Appreciate the importance of powder metallurgy technology for production of materialsand components in comparison with other fabrication techniques.
- **CO-2:** List out the advantages, limitations and applications of powder metallurgy technique.
- **CO-3:** Able to choose the production method to get the required size and shape of the powders.

- **CO-4:** Knowledge of various characterization methods to control the properties of the powders.
- **CO-5:** Describe the consolidation and sintering processes in powder metallurgy route.
- **CO-6:** Can develop and design powder metallurgical components for specific applications andneeds of various industries.

Course Outcome No	Statement	Knowledge Level (KL)
CO1	Appreciate the importance of powder metallurgy technology for production of materials and components in comparison with other fabrication techniques.	K1
CO2	List out the advantages, limitations and applications of powder metallurgy technique.	K3
CO3	Able to choose the production method to get the required size and shape of the powders.	K6
CO4	Knowledge of various characterization methods to control the properties of the powders.	K4
CO5	Describe the consolidation and sintering processes in powder metallurgy route.	K2
CO6	Can develop and design powder metallurgical components for specific applications andneeds of various industries.	K3

KL – Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1- Remember, K_2 – Understand, K_3 – Apply, K_4 – Analyze, K_5- Evaluate, K_6 – Create

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3			3				2	1			
CO2	2				1		1	3	3			
CO3	3		2	3				1	1			
CO4												
CO5												
CO6												
CO Average	2.66		2	3	1		1	2	1.66			

3 - High; 2 - Medium; 1 – Low

Text Books:

1. Powder Metallurgy, 2nd Edition - A.K. Sinha, Dhanpat Rai Publications, 2016.
2. Powder Metallurgy Technology - G S Upadhyaya, published by Cambridge International Science Publishing Ltd., 1998.

Reference Books:

1. Introduction to Powder Metallurgy, 1st Edition – J.S. Hirshhorn published by American Powder Metallurgy Institute, 1969.
2. Powder Metallurgy: Principles and Applications – Lenel, Fritz V, published by Metal Powder Industry, 1980.
3. Powder Metallurgy: Practice and Applications, 1st Edition – Sands, R. L. and C.R. Shakespeare, published by George Newnes Limited, 1966.
4. Powder Metallurgy Science by Randall M. German, published by Metal Powder Industry, 1994.
5. Powder Metallurgy: Science, Technology and Applications, 2nd Edition – P.C. Angelo, R. Subramanian and B. Ravisankar, published by PHI Learning, 2022.

FUELS, FURNACES AND REFRACTORIES LAB

II Year B.Tech. 4th -Sem

Course Objectives:

This laboratory course deals with:

1. Analysis of fuels and their importance.
2. Characterization of refractories.
3. Use different types of fuel testing equipment.

List of Experiments:

1. Proximate analysis of Coal (percentage of moisture, volatile matter, ash content & Fixed Carbon).
2. Ultimate analysis of Coal (Carbon, hydrogen, sulfur and oxygen).
3. Determination of Flash and Fire points of diesel using PENSKY MARTINS open and closed cup apparatus.
4. Determination of Flash and Fire points of kerosene using PENSKY MARTINS open and closed cup apparatus.
5. Determination of Flash and Fire points of diesel using ABEL's apparatus.
6. Determination of Flash and Fire points of kerosene using ABEL's apparatus.
7. Determine the effect of kinematic viscosity of lubricant oil by using Red - wood Viscometer-I.
8. Determine the effect of kinematic viscosity of lubricant oil by using Red - wood Viscometer-II.
9. Determine the calorific value of coal by using "Bomb Calorimeter".
10. Determination of apparent density of refractories.

Course Outcomes:

At the end of the course the student would be able to:

1. Gain hands-on experience on the equipment that facilitate property evaluation of fuels, and refractories.
2. Choose the fuels and refractories for specific use in construction and operation of different

furnaces.
3. Select fuels, refractories to minimize overall cost of production for given applications.
4. Operate various types of fuel testing equipment and analyze the observations recorded.

PRINCIPLES OF EXTRACTIVE METALLURGY LAB

II Year B.Tech. 4th -Sem

Pre-Requisites: Principles of Extractive Metallurgy

Course Objectives:

1. This is course is design to give knowledge about different types of extraction processes.
2. Know the importance of EMF series.

List of Experiments

1. Important flow sheets for Metal Extraction.
2. Electro Cleaning of a given material by using electrolysis principle.
3. Electro Etching of a given material by using electrolytic cell.
4. Electro polishing of a given material by using electrolytic cell.
5. Importance of EMF series.
6. Calculate cathode current efficiency electro plating of Copper.
7. Calculate cathode current efficiency electroplating of Nickel.
8. Galvanization of Zinc on mild steel.
9. Electrowinning of Copper by using aqueous electrolyte.
10. Electrowinning of Copper by using prepared electrolyte from raw materials.

Course Outcomes:

1. To study the importance of EMF series.
2. Understand different types of electro cleaning, electro etching, electro polishing techniques.
3. Study the concepts of metal extraction processes.
4. To calculate cathode current efficiency of electroplating of metals.
5. To perform electrowinning of Cu by different electrolytes.
6. To perform galvanisation of Zinc.

BUSINESS ECONOMICS & FINANCIAL ANALYSIS

III Year B.Tech. 5th -Sem

Course Objective:

1. to prepare engineering students to analyze cost/ revenue/ financial data and to make economicand financial analysis in decision making process
2. to examine the performance of companies engaged in engineering.

Module - 1:

Macro Economic Concepts: Economics- Micro & Macroeconomics-National Income Accounting - Methods of Estimation- Various Concepts of National Income - Inflation – Causes of Inflation and Measures to Control Inflation - New Economic Policy - Industrial policy, Trade policy, and Fiscal policy and its Impact on Industry-Types of companies-Features.

Module - 2:

Introduction to Business Economics- Basic Principles of Economics– Fundamental Concepts- Demand – Demand Determinants - Law of Demand- Demand Forecasting and Methods- Elasticity of Demand– Supply- Elasticity of Supply- Theory of Firm.

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Module - 3:

Production, Cost, Market Structures & Pricing:

Production Analysis: Factors of Production, Production Function, Production Function with one variable input, two variable inputs, Returns to Scale, Different Types of Production Functions. Cost analysis: Types of Costs, Short run and Long run Cost Functions. Market Structures: Nature of Competition, Features of Perfect competition, Monopoly, Oligopoly, and Monopolistic Competition. Pricing: Types of Pricing, Product Life Cycle based Pricing, Break Even Analysis, Cost Volume Profit Analysis (simple problems).

Module - 4:

Introduction to Accounting: Accounting Principles (GAPP), concepts, conventions- - Double entry system of Book keeping–Accounting rules- Journal- ledger- Trial balance- Trading and Profit and Loss account- Balance Sheet. (Simple Problems).

Module - 5:

Capital Budgeting Techniques: Significance of Capital Budgeting - cash flows-Time Value of Money- Choosing between alternative investment proposals- Methods of Appraisal Techniques- Pay Back Period - Average Rate of Return – Net Present Value- Internal Rate of Return – Profitability Index (simple problems).

Course Outcomes:

At the end of the course the student will be able to:

- **CO-1:** To perform and evaluate present and future worth of the alternate projects and to appraise projects by using traditional and DCF Methods.
- **CO-2:** To carry out cost benefit analysis of projects and to calculate BEP of different alternative projects.

Course Outcome No	Statement	Knowledge Level (KL)
CO1	To perform and evaluate present and future worth of the alternate	K1

	projects and to appraise projects by using traditional and DCF Methods.	
CO2	To carry out cost benefit analysis of projects and to calculate BEP of different alternative projects.	K3

KL – Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1- Remember, K_2 – Understand, K_3 – Apply, K_4 – Analyze, K_5- Evaluate, K_6 – Create

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3			3				2	1			
CO2	2				1		1	3	3			
CO3	3		2	3				1	1			
CO4												
CO5												
CO Average	2.66		2	3	1		1	2	1.66			

3 - High; 2 - Medium; 1 – Low

Suggested Readings:

1. Henry Malcom Steinar-Engineering Economics, Principles, McGraw Hill Pub.
2. D.D.Chaturvedi, S.L.Gupta, Business Economics - Theory and Applications, International Book House Pvt. Ltd. 2013.
3. Jain and Narang" Accounting, Kalyani Publishers.
4. Arora, M.N." Cost Accounting, Vikas Publication.
5. S.N.Maheshwari, Financial Management, Vikas Publishing House.

LIGHT METALS & ALLOYS

III Year B.Tech. 5th -Sem

Pre-Requisites: Nil

Course Objectives:

This course is mainly intended:

1. To give an exposure of various alloy systems, phase diagrams and their applications.
2. To highlight the importance of alloy selection.
3. To demonstrate the influence of composition, processing and microstructural effect on properties of the nonferrous alloys.

Module -1

Aluminium alloys: Classification, Properties and applications, Physical metallurgy of Al-Cu

alloys, Al-Mg alloys, Al-Zn alloys, Al-Mn alloys, Al-Si alloys, Al-Li alloys, Ternary alloys, Al-Cu-Mg alloys, Al-Si-Mg alloys and Al-Zn-Mg alloys.

Module -2

Magnesium Alloys: Classification, properties and applications, Alloying elements to magnesium and their purpose, Designation of magnesium alloys, Mg-Al-Zn alloys, Corrosion resistance of Mg-alloys.

Module -3

Zinc Alloys: Classification, Properties and applications. Alloying elements to zinc and their purpose. Designation of Zinc alloys.

Module -4

Titanium alloys: Classification, properties and applications, Ti-6Al-4V, Ti-8Al-1Mo-1V, Ti-13V-11Cr-3Al alloys. Titanium alloys for aerospace and aero engine applications.

Module -5

Beryllium alloys: Classification properties and applications, Al-Be alloys, Corrosion resistance of Beryllium alloys.

Course Outcomes:

At the end of the course the student will be able to:

- **CO-1:** To perform and evaluate present and future worth of the alternate projects and to appraise projects by using traditional and DCF Methods.
- **CO-2:** To carry out cost benefit analysis of projects and to calculate BEP of different alternative projects.

Course Outcome No	Statement	Knowledge Level (KL)
CO1	Able to classify Aluminum alloys and understand the importance of structure - propertycorrelation in binary and ternary alloys.	K1
CO2	Knowledge of Magnesium and Zinc alloys and their applications.	K3
CO3	List out the properties of Titanium and its alloys and comprehend their usage.	K1
CO4	Analyze the importance of properties and applications of Beryllium alloys.	K4
CO5	Can develop and design stronger and safer new light weight alloys with the knowledge of metal properties for specialized applications with minimum consumption of materials.	K3

KL – Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1- Remember, K_2 – Understand, K_3 – Apply, K_4 – Analyze, K_5- Evaluate, K_6 – Create

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3			3				2	1			
CO2	2				1		1	3	3			
CO Average	2.5			3	1		1	2.5	2			

3 - High; 2 - Medium; 1 – Low

Text Books:

1. Light alloys: Metallurgy of the Light Metals, 5th Edition - Ian Polmear, David St.John, Jian-Feng Nie, Ma Qian published by Butterworth-Heinemann, 2017.
2. Introduction to Physical Metallurgy, 2nd Edition – Sidney H. Avner, published by McGraw Hill Education, 2017

Reference Books:

1. Heat Treatment, structure and properties of Nonferrous Alloys - Charlie R. Brooks, Published by ASM International, 1982.
2. Engineering Physical Metallurgy, 1st Edition – Lakhtin published by CBS Publishers and Distributors Pvt. Ltd., 2005.
3. ASM Metals Handbook Vol-1 & 2, 1990.
4. Metallurgical Abstracts on Light Metals and Alloys, Volume – 32 - Keikinzoku Shōgakukai, published by Light Metal Educational Foundation, 1999.

HEAT TREATMENT AND PHASE TRANSFORMATIONS

III Year B.Tech. 5th -Sem

Pre-Requisites: Physical Metallurgy

Course Objectives:

1. This course is mainly designed to impart knowledge about basic principles and process variables of different heat treatment processes.
2. Thermo mechanical treatment, Surface hardening techniques, heat treatment of steels, cast irons, non ferrous alloys will also be dealt in detail.
3. Identification of heat treatment defects and related knowledge of heat treatment furnaces will also be dealt in detail.

Module -1

Principles of Heat Treatment of steels, Formation of Austenite on heating, Austenitic grain size, determination and decomposition of austenite. TTT and CCT curves. Effect of alloying elements on TTT curves and Fe-Fe_3C diagram. Phase Transformations: Pearlitic Transformation, Bainitic Transformation, Martensitic Transformation, Order-disorder transformation, Spinodal decomposition.

Module -2

Annealing, Normalizing, Hardening and tempering. Mechanism of heat removal during quenching, quenching media, size effect and mass effect. Tempering and its stages, Austempering, Martempering, Subzero treatment, Patenting. Hardenability of steels, Factors affecting and its determination.

Module -3

Surface Hardening: Principles and Applications of Carburizing, Nitriding, Carbonitriding, Nitrocarburizing, Boronizing and Aluminizing; Flame, Induction and Laser surface hardening.

Module –4

Thermo-mechanical treatments: HTMT, LTMT, Ausforming, Isoforming, Cryoforming.Heat-Treatment of Cast Irons.

Module -5

Heat-Treatment of Copper and its alloys and Aluminium and its alloys.
Heat treatment furnaces, types and applications, Atmospheres, Heat treatment defects and remedies.

Course Outcomes:

At the end of the course the student will be able to:

- **CO-1:** To perform and evaluate present and future worth of the alternate projects and to appraise projects by using traditional and DCF Methods.
- **CO-2:** To carry out cost benefit analysis of projects and to calculate BEP of different alternative projects.

Course Outcome No	Statement	Knowledge Level (KL)
CO1	Apply and interpret phase and continuous cooling diagrams information to assess the impact of a range of heat treatment procedures.	K1
CO2	Demonstrate a critical understanding of the importance of heat treatment in achieving it forpurpose in metals and alloys.	K3
CO3	Learn the fundamentals of microstructure modifications through thermo mechanical andsurface heat treatment processes to achieve the desired properties.	K1
CO4	Propose suitable heat treatment procedures for non ferrous metals like Cu, Al etc.	K4
CO5	Identify and give reasons for the heat treatment defects and explain the various heattreatment furnaces and atmospheres.	K3
CO6	Correlate the microstructure properties, processing and performance of alloys	K3

KL – Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1- Remember, K_2 – Understand, K_3 – Apply, K_4 – Analyze, K_5- Evaluate, K_6 – Create

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3			3				2	1			
CO2	2				1		1	3	3			
CO3	3		2	3				1	1			
CO4												
CO5												
CO6												
CO Average	2.66		2	3	1		1	2	1.66			

3 - High; 2 - Medium; 1 – Low

Text Books:

1. Heat Treatment Principle and Techniques, 2nd edition – T.V. Rajan, C.P. Sharma, Ashok Sharma, 2011.
2. Phase Transformations in Metals and Alloys, 4th edition - David A. Porter, Kenneth E. Easterling, and Mohamed Y. Sherif, CRC Press, Taylor & Francis Group, 2021

Reference Books:

1. Heat Treatment of Metals - Vijendra Singh, Standard Publishers Distributors, 2020.
2. Engineering Physical Metallurgy –Y. Lakhtin, CBS Publishers & Distributors, 2009.
3. Physical Metallurgy for Engineers - R. Varney Wilbur Donald S. Clark, published by Affiliated East-West Press (Pvt.) Ltd, 2018.
4. Physical Metallurgy Principles - Robert E. Reed-Hill, published by Affiliated East-West Press, 2008.

METAL CASTING

III Year B.Tech. 5th -Sem

Course Objectives:

This course is mainly intended to

1. Introduce and explain various moulding, casting techniques and equipment used.
2. Principles of Solidification of casting, defects in castings and their remedies are also dealt in detail.

Module - 1

Introduction to Foundry, Types of foundries - Steps involved in casting. Pattern types, allowances for pattern, pattern materials.

Moulding methods and processes - materials, equipment, Moulding sand ingredients, sand preparation and control, testing, cores and core making - its types.

Module - 2

Sand castings - Green and dry, pressure die casting, Gravity die casting, permanent mould casting, centrifugal casting, precision investment casting, shell Moulding, CO_2 Moulding. Continuous casting and squeeze casting.

Module -3

Purpose of the gating system, Components of gating system and its functions, Types of Risers and Runners. Design of gating system, Types of gates, Gating ratio and its functions, Gating systems and their characteristics.

Module - 4

Solidification time and Chvorinov's rule, concept of progressive and directional solidifications, Metallurgical aspects of Casting. Types of Melting furnaces- crucibles, oil fired furnaces, electric furnaces and cupola, calculation of cupola charges, Degasification, inoculation, pouring techniques.

Module - 5

Gray Cast iron- effect of chemical composition, carbon equivalent, and effect of alloying. Production of gray Cast Iron, ductile iron and malleable iron castings. Melting of Aluminium and Copper alloys. Casting defects arising due to moulding, coring, melting and pouring practice.

Course Outcomes:

At the end of the course the student will be able to:

- **CO-1:** Have fundamental knowledge of possibilities of using castings in different practicalapplications from their design and material point of view.
- **CO-2:** Understand different types of pattern, core and mould making processes.
- **CO-3:** Have basic knowledge of casting and its gating system.
- **CO-4:** Evaluate the effect of chemical composition of grey cast iron and casting defects.

Course Outcome No	Statement	Knowledge Level (KL)
CO1	Have fundamental knowledge of possibilities of using castings in different practicalapplications from their design and material point of view.	K1
CO2	Understand different types of pattern, core and mould making processes.	K3
CO3	Have basic knowledge of casting and its gating system.	K1
CO4	Evaluate the effect of chemical composition of grey cast iron and casting defects.	K4

KL – Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1- Remember, K_2 – Understand, K_3 – Apply, K_4 – Analyze, K_5- Evaluate, K_6 – Create

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3			3				2	1			
CO2	2				1		1	3	3			
CO3	3		2	3				1	1			
CO4												
CO5												
CO6												
CO Average	2.66		2	3	1		1	2	1.66			

3 - High; 2 - Medium; 1 – Low

Text Books:

1. Principles of Metal Casting - Heine, Loper and Rosenthal, Tata Mc Graw Hill Publishing Co, Ltd; New Delhi, 1995.
2. Foundry Technology - Peter Beeley, Elsevier Science Publisher, 2001

Reference Books:

1. Foundry Technology - Dharmendra Kumar / S.K.Jain, CBS Publisher, 2007.
2. Metal Casting: Principles and Practice, 1st edition by T.V. Ramana Rao, Newagepublishers,1996,
3. Principles of Foundry Technology, 5th edition by P. L. Jain, published by McGraw Hill Education, 2017

STEEL MAKING

III Year B.Tech. 5th -Sem
Pre-requisites: Iron Making, Metallurgical Thermodynamics - I

Course Objectives:

1. Discuss the evolution of steel making processes in chronological order.
2. Illustrate the applications of thermodynamics and kinetics in production of steel making.
3. Outline the techniques for production and primary processing in steel making.
4. Explain the casting processes for steel.

Module - 1

Classification of Steel making Processes. Raw materials for steel making. Factors affecting the efficiency of steel making. Principles of Steel Making - Decarburisation, Desiliconization. Dephosphorisation and Desulphurisation. Deoxidation practice. Molecular and ionic theory of slags.

Module - 2

Bessemer and open-hearth steel making processes, electric arc steel making.

Module - 3

LD, LD - AC steel making processes. Bottom blown O_2 processes. Combined blow processes.

Module - 4

Casting pit side practice, Teeming methods. Solidification of steels – killed steels, semi killed steels and Rimming steels. Ingot defects and remedies.

Module - 5

Secondary steel making processes - Vacuum treatment of steels**:** RH and DH process. Continuous casting of steels.

Course Outcomes:

At the end of the course the student will be able to:

- **CO-1:** Knowledge and analyze the effect of input variables on quantity and quality of steelproduction
- **CO-2:** Illustrate the constructional details of various furnaces used in steel making and design plantlay outs.
- **CO-3:** Judge the role of slag chemistry on quality of steel.
- **CO-4:** Know and apply principles of modern environmental friendly production techniques.
- **CO-5:** Able to undertake any technical assignment in R&D and production units with professionalresponsibility towards profession and society.

Course Outcome No	Statement	Knowledge Level (KL)
CO1	Knowledge and analyze the effect of input variables on quantity and quality of steelproduction	K1
CO2	Illustrate the constructional details of various furnaces used in steel making and design plantlay outs.	K3
CO3	Judge the role of slag chemistry on quality of steel.	K1
CO4	Know and apply principles of modern environmental friendly production techniques.	K4
CO5	Able to undertake any technical assignment in R&D and production units with professionalresponsibility towards profession and society.	K3

KL – Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1- Remember, K_2 – Understand, K_3 – Apply, K_4 – Analyze, K_5- Evaluate, K_6 – Create

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12

CO1	3			3				2	1			
CO2	2				1		1	3	3			
CO3	3		2	3				1	1			
CO4												
CO5												
CO6												
CO Average	2.66		2	3	1		1	2	1.66			

3 - High; 2 - Medium; 1 – Low

Text Book:

1. Iron Making and Steel Making – Theory and practice - Ahindra Ghosh and Amit Chatterjee published by Prentice Hall India Learning Pvt. Ltd, 2008.
2. An Introduction to Modern Steel Making, 7th Edition – Dr. R. H. Tupkary and V. R. Tupkary, Khanna Publishers, 2000.

Reference Books:

1. Steel Making - A.K. Chakrabarti, published by Prentice Hall India Learning Pvt. Ltd, 2006.
2. Steel Making - V.A. Kudrin, Mir Publishers, 1985.

INTELLECTUAL PROPERTY RIGHTS

III Year B.Tech. 5th - Sem

Module – 1

Introduction to Intellectual property: Introduction, types of intellectual property, international organizations, agencies and treaties, importance of intellectual property rights.

Module – 2

Trade Marks: Purpose and function of trademarks, acquisition of trade mark rights, protectable matter, selecting, and evaluating trade mark, trade mark registration processes.

Module – 3

Law of copy rights: Fundamental of copy right law, originality of material, rights of reproduction, rights to perform the work publicly, copy right ownership issues, copy right registration, notice of copy right, international copy right law.

Law of patents: Foundation of patent law, patent searching process, ownership rights and transfer

Module – 4

Trade Secrets: Trade secret law, determination of trade secrete status, liability for

misappropriations of trade secrets, protection for submission, trade secrete litigation.
Unfair competition: Misappropriation right of publicity, false advertising.

Module – 5

New development of intellectual property: new developments in trade mark law; copy right law, patent law, intellectual property audits.
International overview on intellectual property, international – trade mark law, copy right law, international patent law, and international development in trade secrets law.

Text & Reference Books:

1. Intellectual property right, Deborah. E. Bouchoux, Cengage learning.
2. Intellectual property right – Unleashing the knowledge economy, prabuddha ganguli, Tata McGraw Hill Publishing company ltd.

METAL CASTING LAB

III Year B.Tech. 5th - Sem

Course Objectives:

1. This lab course is designed to provide hands on experience on various foundry testing methods for evaluation of moulding sand properties.

LIST OF EXPERIMENTS:

1. Preparation of gating system using green sand.
2. Study of particle size distribution of the sand.
3. Study of the variation of permeability of the green sand with clay and water.
4. Determination of the variation of sand properties like green hardness, green compact strength with additives in sands.
5. Determination of the variation of hot compact hardness and hot shear strength with additives in sands.
6. Determination of clay content in sand.
7. Determination of the shatter index of green sand.
8. Melting and casting of Aluminum alloys.
9. Melting and casting of Cast Iron.
10. Charge calculations of cast iron in a cupola.
11. Non-destructive testing of cast iron components.

Course Outcomes:

1. Broad knowledge about different types of pattern materials and designing of patterns.
2. Understand different methods of particle size measurement and properties measurements.
3. Determination of clay content present in the mould sand.
4. Understanding of different Nondestructive techniques for testing of materials.
5. Able to prepare patterns with sand.

6. Able to operate cupola furnace.

HEAT TREATMENT AND PHASE TRANSFORMATIONS LAB

III Year B.Tech. I-Sem

Pre-Requisites: Heat Treatment and Phase Transformations

Course Objectives:

This course is mainly designed to

1. To conduct various heat treatment processes, surface hardening techniques and age hardening processes on different materials.
2. Gain knowledge of phase transformations taking place under various conditions of heat treatment.

List of Experiments:

1. Annealing of plain carbon steel and observation of microstructure.
2. Normalizing of plain carbon steel and observation of microstructure.
3. Hardening of plain carbon steel with quenching in water and brine solution and observation of microstructures.
4. Hardening of plain carbon steel with quenching in oil and observation of microstructure.
5. Effect of tempering temperature on plain carbon steel.
6. Effect of tempering time on plain carbon steel.
7. Age hardening of Aluminium - Copper alloys.
8. Spheroidizing of a given high carbon steel.
9. Surface hardening of plain carbon steel.
10. Determination of hardenability of medium carbon steel by Jominy end quench test.
11. Determination of phase fraction and grain size using Image analyzer.

Course Outcomes:

At the end of the course the student will be able to:

1. Conduct heat treatment in furnaces under suitable/ required time, temperature and atmospheric conditions.
2. Modify the microstructures of metals and alloys through heat treatment practice for obtaining desired properties in present and future.
3. To modify the surface properties of steels.
4. To determine hardenability by performing Jominy end quench test
5. Analyze, correlate and interpret the results obtained in the tests conducted.
6. Report the observations in a formal manner.

NON-FERROUS EXTRACTIVE METALLURGY

III Year B.Tech. 6th -Sem

Pre-Requisites: Mineral Dressing and Principles of Extractive Metallurgy

Course Objectives:

1. To explain the various methods of extraction of non ferrous metals.
2. To draw the flow sheets for extraction of various non ferrous metals.
3. To describe the procedure and equipment used for production of non ferrous metals from their ores.

Module -1

Copper: Principal Ore and Minerals; Matte smelting – Blast furnace, Reverberatory; Electric furnace, Flash; Converting; Continuous production of blister Copper; Fire refining; Electrolytic refining, Hydro-Metallurgical copper extraction, Leaching processes, Recovery of copper from leach solutions, Electro-winning.

Module -2

Zinc: General Principles: Horizontal and vertical retort processes, Production in a Blast furnace, Leaching purification, Electrolysis, Refining.
Lead: Blast furnace smelting, Refining of lead bullion.

Module -3

Aluminium: Bayer process: Hall - Heroult process: Anode effect: Efficiency of the process: Refining, Alternative processes of aluminum production.

Module -4

Magnesium: Production of a hydrous Magnesium chloride from seawater and magnesite. Electro-winning practice and problem, refining, Pidgeon and Hansgrig processes.
Titanium: Upgrading of ilmenite, chlorination of titania, Kroll's process. Refining.

Module -5

Uranium: Acid and alkali processes for digestion of uranium ores, Purification of crude salt, Production of reactor grade UO_2 and uranium.
Simplified flow sheets for the extraction of nickel, tungsten and gold. Review of non-ferrous metal industries in India.

Course Outcomes:

At the end of the course the student will be able to:

- **CO-1:** Get detailed information about the properties of non ferrous metals, ores of non ferrous metals, pre treatment processes, thermodynamics and kinetics involved in extraction process.
- **CO-2:** Describe and explain ore treatment techniques and learn the fundamental concepts of metallurgical pre-treatment methods, production of metals from ore, concentrate and secondary sources.

- **CO-3:** Emphasize the strategic importance of raw and supplementary materials in the production,and explain the concepts of technological and economical feasibility.
- **CO-4:** Identify the beneficiation of by products materialize during the metal production, within the framework of technology-environment-ecology.
- **CO-5:** Explain processes based on an advanced thermodynamic perspective and explain materialand energy flows related to extraction of metals and alloys.
- **CO-6:** Understand about Extractive metallurgy processes and explain their relative merits and demerits and also conduct a detailed and individual research about production of a specificmetal, as part of their responsibility.

Course Outcome No	Statement	Knowledge Level (KL)
CO1	Get detailed information about the properties of non ferrous metals, ores of non ferrous metals, pre treatment processes, thermodynamics and kinetics involved in extraction process.	K1
CO2	Describe and explain ore treatment techniques and learn the fundamental concepts of metallurgical pre-treatment methods, production of metals from ore, concentrate and secondary sources.	K3
CO3	Emphasize the strategic importance of raw and supplementary materials in the production, and explain the concepts of technological and economical feasibility.	K1
CO4	Identify the beneficiation of by products materialize during the metal production, within the framework of technology-environment-ecology.	K4
CO5	Explain processes based on an advanced thermodynamic perspective and explain material and energy flows related to extraction of metals and alloys.	K3
CO6	Understand about Extractive metallurgy processes and explain their relative merits and demerits and also conduct a detailed and individual research about production of a specific metal, as part of their responsibility.	K2

KL – Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1- Remember, K_2 – Understand, K_3 – Apply, K_4 – Analyze, K_5- Evaluate, K_6 – Create

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3			3				2	1			
CO2	2				1		1	3	3			
CO3	3		2	3				1	1			
CO4												
CO5												
CO6												
CO Average	2.66		2	3	1		1	2	1.66			

3 - High; 2 - Medium; 1 – Low

Text Books:

1. Extraction of Non-Ferrous Metals – H.S. Ray, K.P. Abraham and R. Sridhar, Published by East West Press, 2020.
2. Metallurgy of Non-Ferrous Metals, 1st edition – W.H. Dennis, published by Sir Isaac Pitman & Sons Ltd, 1954.

Reference Books:

1. Rare Metals Hand book, 2nd Edition - Clifford A. Hampel, Published by Krieger Publishing Company, 1971.
2. Nuclear Reactor General Metallurgy, 1st Edition - B. Kuznetsov Sevryukov N, Kuzmin B, Chelishchev - Peace Publishers, 1965.
3. Nuclear Chemical Engineering, 2nd Edition - Manson Benedict, Thomas Pigford, Hans Levi, Published by McGraw-Hill Education, 1981.

METAL FORMING

III Year B.Tech. 6th -Sem

Pre-requisites: Mechanical Metallurgy

Course Objective:

1. Gain an understanding of fundamentals of metal working.
2. Analyze the behavior of metals during plastic deformation.
3. Obtain a working knowledge of forging, rolling, extrusion, and wiredrawing.

Module -1

FUNDAMENTALS OF METAL WORKING: Classification of forming processes, Mechanics of metal working for slab method and uniform deformation energy method. Cold working, Recovery, Recrystallization and grain growth, hot working, Strain-Rate effects, Work of plastic deformation.

Module - 2

FORGING: Classification of forging processes, forging equipment. Forging in plane strain. Open-die forging, closed-die forging, Forging of a cylinder in plane-strain. Forging defects, powder metallurgy forging.

Module -3

ROLLING OF METALS**:** Classification of rolling processes, rolling mills. Hot rolling, cold rolling, rolling of bars and shapes, forging and geometrical relationships in rolling.
Simplified analysis of rolling load, rolling variables, problems and defects in rolled products. Theories of hot rolling, torque and horsepower, theories of cold rolling, torque and horsepower.

Module -4

EXTRUSION: Classification of extrusion processes, extrusion equipment. Hot extrusion. Deformation and defects in extrusion. Analysis of extrusion process. Cold extrusion. Extrusion of tubing and production of seamless pipe and tubing.

Module -5

Rod and wire drawing, tube drawing processes, residual stresses in rod, wire and tubes. Sheet metal forming processes.

Course Outcomes:

At the end of the course the student will be able to:

- **CO-1:** Compare and classify different forming processes.
- **CO-2:** Analyze the behaviour of materials during forming processes.
- **CO-3:** Determine forming processes controlling parameters.
- **CO-4:** Estimate required forming loads, powers of different forming equipment and processes.
- **CO-5:** Determine the cause of the defects that may take place during forming processes.
- **CO-6:** Integrate knowledge gained in this course to select and design a complete metal formingsystem.

Course Outcome No	Statement	Knowledge Level (KL)
CO1	Compare and classify different forming processes.	K1
CO2	Analyze the behaviour of materials during forming processes.	K3
CO3	Determine forming processes controlling parameters.	K1
CO4	Estimate required forming loads, powers of different forming equipment and processes.	K4
CO5	Determine the cause of the defects that may take place during forming processes.	K3
CO6	Integrate knowledge gained in this course to select and design a complete metal formingsystem.	K2

KL – Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1- Remember, K_2 – Understand, K_3 – Apply, K_4 – Analyze, K_5- Evaluate, K_6 – Create

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3			3				2	1			
CO2	2				1		1	3	3			
CO3	3		2	3				1	1			
CO4												

CO5												
CO6												
CO Average	2.66		2	3	1		1	2	1.66			

3 - High; 2 - Medium; 1 – Low

Text Books:

1. Mechanical Metallurgy, 3rd Edition - by George E. Dieter, Published by McGraw Hill Education, 2017.
2. Engineering Metallurgy (Part-II) – Raymond Aurelius Higgins, Published by English Universities Press, 1960

Reference Books:

1. Fundamentals of Metal Forming Processes, 2nd Edition – B.L. Juneja, New age International Publishers, 2018.
2. Technology of Metal Forming Processes – Surender Kumar, PHI publication, 2008.
3. Handbook of Metal Forming Process - Darren Wang, published by NY Research Press, 2015.

METAL JOINING

III Year B.Tech. 6th -Sem

Course Objectives:

1. To provide with the knowledge on basics of joining processes
2. To gain the knowledge on the Gas and Arc welding and Resistance and Pressure welding processes.
3. To gain the knowledge on the special welding processes and soldering and brazing techniques.
4. To gain hands on experience on inspection and testing of weldments.

Module -1

Basic Science of Welding Processes. Sources of heat energy, the flame, the electric arc. Chemical reactions during welding, oxidation reaction, protection of weld pool with fluxes or gases. Microstructural changes during welding, the effect of heat on metals. Pre-treatment and post-treatment of welds.

Module -2

Gas and Arc Welding processes: Classification of welding processes- fusion welding processes, oxy-acetylene welding, arc welding-manual, submerged arc welding, gas tungsten arc and gas metal arc welding; practice, joint design and preparation and their advantages and disadvantages

Module -3

Resistance and Pressure Welding processes: Pressure welding- Cold and hot pressure welding, friction and friction stir welding, and diffusion welding. Resistance welding- spot and projection welding; practice, joint design and preparation and their advantages and disadvantages.

Module -4

Special welding processes: Principle, equipment, process variables, merits, Limitations and applications of Electron beam, plasma arc and laser beam welding processes.

Soldering and Brazing: Principles and practices.

Module -5

Concept of Weldability and its assessment, dilution**.**

Inspection of Weld Joints. Non-destructive testing.

Weld defects- their causes and remedies.

Course Outcomes:

At the end of the course the student will be able to:

- **CO-1:** Know the basic science of welding processes and list out their types and the principles guiding the operations. Appreciate the effect of welding parameters on the structure and mechanical properties of welded parts.
- **CO-2:** Identify different energy sources like electron beam, laser beam, plasma arc, explosion welding, ultrasonic welding etc and analyze the concept, mechanism, parameters associatedwith the processes.
- **CO-3:** Demonstrate weld design procedures and also describe soldering and brazing techniques convincingly.
- **CO-4:** Categorize different welding techniques for metals, alloys, non metals, dissimilar metals etc.,
- **CO-5:** Understand the causes of welding defects and how they can be prevented.
- **CO-6:** Selectively select a process for a specific application/ need/situation depending upon the availability of sources.

Course Outcome No	Statement	Knowledge Level (KL)
CO1	Know the basic science of welding processes and list out their types and the principles guiding the operations. Appreciate the effect of welding parameters on the structure and mechanical properties of welded parts.	K1
CO2	Identify different energy sources like electron beam, laser beam, plasma arc, explosion welding, ultrasonic welding etc and analyze the concept, mechanism, parameters associatedwith the processes.	K3
CO3	Demonstrate weld design procedures and also describe soldering and brazing techniques convincingly.	K1
CO4	Categorize different welding techniques for metals, alloys, non metals,	K4

	dissimilar metals etc.,	
CO5	Understand the causes of welding defects and how they can be prevented.	K3
CO6	Selectively select a process for a specific application/ need/situation depending upon the availability of sources.	K2

KL – Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1- Remember, K_2 – Understand, K_3 – Apply, K_4 – Analyze, K_5- Evaluate, K_6 – Create

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3			3				2	1			
CO2	2				1		1	3	3			
CO3	3		2	3				1	1			
CO4												
CO5												
CO6												
CO Average	2.66		2	3	1		1	2	1.66			

3 - High; 2 - Medium; 1 – Low

Text Books:

1. Welding Processes and Technology, 3rd Edition, - Dr. R.S. Parmar, Khanna Publishers, 2013.
2. Modern Welding Technology, 4th edition - Howard B. Cary, Published by Prentice Hall, New Jersey, USA, 1997.

Reference Books:

1. ASM Metals Handbook. Vol.6: Welding Brazing & Soldering - ASM International, Metals Park, Ohio, USA, 1997.
2. "Welding", Vol-2, 10th Edition – A.C. Davies, Published by Cambridge University Press, 2008.
3. Metallurgy of Welding, 3rd Edition - J.F. Lancaster, London George Allen & Unwin, Boston, 1980.

COMPUTATIONAL MATERIALS ENGINEERING
(Elective – I)

III Year B.Tech. 6th -Sem

Course objective:

1. This course introduces computational methods in the domain of metallurgical engineering.
2. To understand the structure property correlations in materials engineering.

3. To understand evolution of materials structure and to control material properties.
4. To calculate the miscellaneous problems by using computational techniques.

Module - 1

Introduction, **Tools of the trade: a short tutorial introduction:** The C programming language, GNU plot – the plotting freeware, GNU Octave for computations and plotting, Introduction to FEM, FDM, FVM and Computer packages: MATLAB, Sci Lab. Plotting, Fitting, Interpolation, Numerical integration, Numerical differentiation.

Module -2

Structure and Thermodynamics: Basics of Mathematical Modelling-Deterministic and stochastic / probabilistic models. Structure and defects. Computing free energy of common metallurgical systems from enthalpy and entropy or heat capacity and determination of temperature of reduction of metal oxides. Regular solution model.

Module - 3

Phase Transformations: Mathematical formulation of Solid state processes of Heat treatment & Microstructure evolution, Diffusion and precipitate growth kinetics. Transport phenomena based Modelling: model formulation based on heat, mass and momentum transfer, governing equations and boundary conditions. Spinodal decomposition, Classical Molecular Dynamics Modelling and simulations and its applications in materials, Monte Carlo simulations: phase separation and ordering.

Module -4

Phase-Field and Heat-Mass Transfer: Mathematical formulation of Liquid state Metallurgical Processes of Iron Making, Primary Steel Making and Secondary Steel Making using Momentum, Mass and Energy Balance. Principles of Computational Fluid flow and setting up the governing equation with boundary conditions. Formulation of Laminar and Turbulent flows. Case Studies of Tapping of Liquid steel, melting behaviour of additions, IGP. Computation of % CO/CO_2 at different heights with a given function of temperature profile along the height of BF and Simulations of Blast furnace reduction reactions at various heights. Mathematical Modeling of Solidification of Steel in Sand Moulds, Ingot Moulds & Concast.

Module -5

New approach: Optimization and control. Elements of modern artificial intelligence (AI) related techniques. Introduction to Genetic Algorithm and Artificial Neural Nets. Dis-critized Methods of Taylor's series expansion, polynomial Interpolation and least square approximation for numerical computation of Non linear algebraic equations, ODE & PDE. Statistical methods for validating models.

Course Outcomes:

At the end of the course the student will be able to:

- **CO-1:** Analyse a metallurgical problem to create a well posed numerical problem.
- **CO-2:** Identify initial and boundary conditions of a problem relevant to materials domain.

- **CO-3:** Propose a solution procedure for a numerical problem in the domain of materialsengineering.
- **CO-4:** Demonstrate ability to quantify a materials engineering problem through numericalanalysis.
- **CO-5:** Select materials for specific applications and also to design advanced materials for newapplications.
- **CO-6:** To use preferred tools at electronic, continuum and structural levels.

Course Outcome No	Statement	Knowledge Level (KL)
CO1	Analyse a metallurgical problem to create a well posed numerical problem.	K1
CO2	Identify initial and boundary conditions of a problem relevant to materials domain.	K3
CO3	Propose a solution procedure for a numerical problem in the domain of materialsengineering.	K1
CO4	Demonstrate ability to quantify a materials engineering problem through numericalanalysis.	K4
CO5	Select materials for specific applications and also to design advanced materials for newapplications.	K3
CO6	To use preferred tools at electronic, continuum and structural levels.	K2

KL – Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1- Remember, K_2 – Understand, K_3 – Apply, K_4 – Analyze, K_5- Evaluate, K_6 – Create

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3			3				2	1			
CO2	2				1		1	3	3			
CO3	3		2	3				1	1			
CO4												
CO5												
CO6												
CO Average	2.66		2	3	1		1	2	1.66			

3 - High; 2 - Medium; 1 – Low

Text Books:

1. Introduction to Computational Materials Science – Richard Lesar, Cambridge University Press publishers, 2013
2. Applied Numerical Methods for Engineers using MATLAB and C - Robert J. Schilling & Sandra L.Harris, Cengage Learning (2007).

Reference Books:

1. Mathematical Methods for Physics and Engineering, 3rd Edition – K.F. Riley, M.P. Hobson and S.J. Bence, Cambridge University Press, 2006.
2. Modeling in Materials Processing – Jonathan A. Dantzig, Charles L. Tucker III, Cambridge University Press Publishers, 2001.
3. Materials Science and Engineering, 5th edition - V Raghavan, published by Prentice-Hall India s, 2004.
4. Advanced Engineering Mathematics, 10th edition - Erwin Kreyszig, Published by Wiley, 2010.
5. Modelling of Steel Making Processes, 1st Edition, - Dipak Mazumdar, James W. Evans, Published by CRC Press, 2010.
6. An Introduction to Computational Fluid Dynamics, 2nd edition - H.K.Versteeg , W. Malalsekera, Pearson Education Limited, 2007.
7. Numerical Methods for Engineers, 7th Edition - Steven C. Chapra and Raymond P. Canale, published by Mc Graw Hill Education, 2015.
8. Handbook of Materials Modelling, 2nd edition, Wanda Andreoni and Sidney Yip published by Springer, 2020.
9. Numerical Methods for Engineers, 4th edition - Santosh K. Gupta, New Age International publishers, New Delhi, 2019.

FERRO ALLOY TECHNOLOGY
(Elective – I)

III Year B.Tech. 6th -Sem

Course Objectives:

The prime objective of the course is to

1. Make the student aware of various ferroalloys their properties and uses.
2. To expose the students to various production methods of ferro alloys.

Module -1

Mechanical equipment of ferro alloy furnaces: Principle elements, Closed top furnaces, Lining of furnaces. Electrical equipment and dimensions of reaction chamber.

Module -2

Manufacture of Ferro – Silicon: Raw materials, furnaces, Physico – chemical conditions of the process, Melt procedure.

Manufacture of Ferro – chrome: Chrome Ores, Methods for making ferro – chrome, High-carbon ferro – chrome, Low-carbon and Extralow carbon ferro – chrome.

Module -3

Manufacture of Ferro – Manganese: High-Carbon Ferro-Manganese, Silicon – Manganese, Medium and Low - Carbon Ferro-Manganese.

Manufacture of Ferro – Vanadium: Recovery of vanadium form Ores, Chemical processing of vanadium slags, Smelting of Ferro-Vanadium.

Module -4

Manufacture of Ferro – Tungsten: Physico - chemical properties of Tungsten, smelting of Ferro-Tungsten.

Manufacture of Ferro – Titanium: Physico - chemical properties of Titanium, smelting of Ferro- Titanium.

Module -5

Manufacture of Ferro – Molybdenum: Physico - chemical properties of Molybdenum, Charge materials and charge preparation and smelting of Ferro- Molybdenum.

Manufacture of Ferro – Boron: Physico - chemical properties of Boron, smelting of Ferro-Boron.

Course Outcomes:

At the end of the course the student will be able to:

- **CO-1:** Can list out the various ferro alloys, their applications, illustrate and know the importanceof design of furnaces.
- **CO-2:** Explain the process/production methods for Ferro – Silicon and Ferro – chrome and thenecessary corrective steps to be taken to overcome the problems arising during production.
- **CO-3:** Describe the raw materials and production for Ferro – Manganese, Ferro – Vanadiumprocess.
- **CO-4:** Describe the smelting procedure of Ferro – Tungsten and Ferro – Titanium.
- **CO-5:** Appreciate the need for recover, reuse, and recycle of by-products.
- **CO-6:** Judge and predict the future of Ferro alloy technology.

Course Outcome No	Statement	Knowledge Level (KL)
CO1	Can list out the various ferro alloys, their applications, illustrate and know the importanceof design of furnaces.	K1
CO2	Explain the process/production methods for Ferro – Silicon and Ferro – chrome and the necessary corrective steps to be taken to overcome the problems arising during production.	K3
CO3	Describe the raw materials and production for Ferro – Manganese, Ferro – Vanadiumprocess.	K1
CO4	Describe the smelting procedure of Ferro – Tungsten and Ferro – Titanium.	K4
CO5	Appreciate the need for recover, reuse, and recycle of by-products.	K3
CO6	Judge and predict the future of Ferro alloy technology.	K2

KL – Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1- Remember, K_2 – Understand, K_3 – Apply, K_4 – Analyze, K_5- Evaluate, K_6 – Create

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12

CO1	3			3				2	1			
CO2	2				1		1	3	3			
CO3	3		2	3				1	1			
CO4												
CO5												
CO6												
CO Average	2.66		2	3	1		1	2	1.66			

3 - High; 2 - Medium; 1 – Low

Text Books:

1. Production of Ferroalloys - Mark Riss. and Yakov. Khodorovsky - Mir Publishers, Moscow 1967.
2. Electrometallurgy of Steel and Ferro alloys - F. P. Edneral, Mir Publishers 1979.

Reference Book:

1. Symposium on ferro alloys - NML Technical Jl. - Feb 1962.
2. Handbook of Ferroalloys Theory and Technology, 1st Edition by Michael Gasik published by Butterworth-Heinemann, 2013.

ENVIRONMENTAL SCIENCE

III Year B.Tech. 6th -Sem

Course Objectives:

1. Understanding the importance of ecological balance for sustainable development.
2. Understanding the impacts of developmental activities and mitigation measures.
3. Understanding the environmental policies and regulations

Module - 1

Ecosystems: Definition, Scope, and Importance of ecosystem. Classification, structure, and function of an ecosystem, Food chains, food webs, and ecological pyramids. Flow of energy, Biogeochemical cycles, Bioaccumulation, Biomagnification, ecosystem value, services and carrying capacity, Field visits.

Module - 2

Natural Resources: Classification of Resources: Living and Non-Living resources, water resources: use and over utilization of surface and ground water, floods and droughts, Dams: benefits and problems. **Mineral resources:** use and exploitation, environmental effects of extracting and using mineral resources, Land resources: Forest resources, Energy resources: growing energy needs, renewable and non-renewable energy sources, use of alternate energy

source, case studies.

Module - 3

Biodiversity and Biotic Resources: Introduction, Definition, genetic, species and ecosystem diversity. Value of biodiversity; consumptive use, productive use, social, ethical, aesthetic and optional values. India as a mega diversity nation, Hot spots of biodiversity. Field visit. Threats to biodiversity: habitat loss, poaching of wildlife, man-wildlife conflicts; conservation of biodiversity: In-Situ and Ex-situ conservation. National Biodiversity act.

Module - 4

Environmental Pollution and Control Technologies: Environmental Pollution: Classification of pollution, Air Pollution: Primary and secondary pollutants, Automobile and Industrial pollution, Ambient air quality standards. **Water pollution:** Sources and types of pollution, drinking water quality standards. **Soil Pollution:** Sources and types, Impacts of modern agriculture, degradation of soil. **Noise Pollution:** Sources and Health hazards, standards, **Solid waste:** Municipal Solid Waste management, composition and characteristics of e-Waste and its management. **Pollution control technologies:** Wastewater Treatment methods: Primary, secondary and Tertiary.
Overview of air pollution control technologies, Concepts of bioremediation. **Global Environmental Issues and Global Efforts:** Climate change and impacts on human environment. Ozone depletion and Ozone depleting substances (ODS). Deforestation and desertification. International conventions / Protocols: Earth summit, Kyoto protocol, and Montréal Protocol. NAPCC-GoI Initiatives.

Module - 5

Environmental Policy, Legislation & EIA: Environmental Protection act, Legal aspects Air Act- 1981, Water Act, Forest Act, Wild life Act, Municipal solid waste management and handling rules, biomedical waste management and handling rules, hazardous waste management and handling rules. EIA: EIA structure, methods of baseline data acquisition. Overview on Impacts of air, water, biological and Socio-economical aspects. Strategies for risk assessment, Concepts of Environmental Management Plan (EMP). Towards Sustainable Future: Concept of Sustainable Development Goals, Population and its explosion, Crazy Consumerism, Environmental Education, Urban Sprawl, Human health, Environmental Ethics, Concept of Green Building, Ecological Foot Print, Life Cycle assessment (LCA), Low carbon life style.

Course Outcomes:

At the end of the course the student will be able to:

- **CO-1:** Based on this course, the Engineering graduate will understand /evaluate / develop technologies on the basis of ecological principles and environmental regulations which inturn helps in sustainable development.

Course Outcome No	Statement	Knowledge Level (KL)
CO1	Based on this course, the Engineering graduate will understand /evaluate / developtechnologies on the basis of ecological principles and environmental regulations which inturn helps in sustainable development.	K1

KL – Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1- Remember, K_2 – Understand, K_3 – Apply, K_4 – Analyze, K_5- Evaluate, K_6 – Create

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3			3				2	1			
CO2	2				1		1	3	3			
CO3	3		2	3				1	1			
CO4												
CO5												
CO6												
CO Average	2.66		2	3	1		1	2	1.66			

3 - High; 2 - Medium; 1 – Low

Text Books:

1. Textbook of Environmental Studies for Undergraduate Courses by Erach Bharucha for University Grants Commission.
2. Environmental Studies by R. Rajagopalan, Oxford University Press.

Reference Books:

1. Environmental Science: towards a sustainable future by Richard T. Wright. 2008 PHL Learning Private Ltd. New Delhi.
2. Environmental Engineering and science by Gilbert M. Masters and Wendell P. Ela. 2008 PHI Learning Pvt. Ltd.
3. Environmental Science by Daniel B. Botkin & Edward A. Keller, Wiley INDIA edition.
4. Environmental Studies by Anubha Kaushik, 4th Edition, New age international publishers.
5. Text book of Environmental Science and Technology - Dr. M. Anji Reddy 2007, BS Publications.
6. Introduction to Environmental Science by Y. Anjaneyulu, BS. Publications.

SURFACE ENGINEERING

III Year B.Tech. 6th -Sem

Pre-Requisites: Physical Metallurgy and Thermodynamics and Kinetics

Course Objectives:

1. To provide a state - of - the art knowledge to the students about the various surface engineering techniques.
2. To explain the importance, need of surface engineering and past, present and future status of surface engineering.
3. To comprehend the laser processing, electrons and ion beam processing of surfaces, to characterize and evaluate coatings etc.
4. To understand the combat techniques to protect the surfaces from wear, corrosion and other failure causing environments.

Module -1

Introduction to surface modification, surface properties, need for surface modification, Classification of surface modification techniques.

Module –2

Plating and coating process: Concept of coating, types of coatings, properties of coatings, hot dipping hard facing, anodizing, physical vapour deposition, chemical vapour deposition, electro-deposition, electro-less deposition

Module -3

Thermo-chemical Processes: Carburizing, Nitriding, Carbo-Nitriding, Nitro Carburizing, Boronising, Plasma Nitriding, Thermal spraying, Plasma spraying, Alumnizing.

Module -4

Thermal Processes: Flame hardening, Induction hardening, laser hardening, laser surface alloying, laser cladding, Electro-beam hardening, shot peening, laser shock peening.

Module -5

General design principles related to surface engineering, design guidelines for surface preparation, surface engineering solution to specific problems. Case studies related to Engineering Components, Shafts, Bearings, Turbine blades.

Course Outcomes:

At the end of the course the student will be able to:

- **CO-1:** Gain knowledge of different surface properties, appreciate the need for surfacemodification and past practices.
- **CO-2:** Knowledge of plating and coatings techniques.
- **CO-3:** Knowledge of surface modification by chemical and thermal processes.
- **CO-4:** Differentiate between the methods used and indicate their relative merits and

demerits

- **CO-5:** This course provides an opportunity to the students to understand the various aspectsassociated with industrial applications of surface engineering.
- **CO-6:** Design various surface modifications according to the needs, compatibility and efficiencyof the processes and the desired output

Course Outcome No	Statement	Knowledge Level (KL)
CO1	Gain knowledge of different surface properties, appreciate the need for surfacemodification and past practices.	K1
CO2	Knowledge of plating and coatings techniques.	K3
CO3	Knowledge of surface modification by chemical and thermal processes.	K1
CO4	Differentiate between the methods used and indicate their relative merits and demerits	K4
CO5	This course provides an opportunity to the students to understand the various aspects associated with industrial applications of surface engineering.	K3
CO6	Design various surface modifications according to the needs, compatibility and efficiencyof the processes and the desired output	K2

KL – Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1- Remember, K_2 – Understand, K_3 – Apply, K_4 – Analyze, K_5- Evaluate, K_6 – Create

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3			3				2	1			
CO2	2				1		1	3	3			
CO3	3		2	3				1	1			
CO4												
CO5												
CO6												
CO Average	2.66		2	3	1		1	2	1.66			

3 - High; 2 - Medium; 1 – Low

Text Books:

1. Advanced Thermal Assisted Surface Engineering Processes - Ramnarayan Chattopadhyay, published by Kluwer Academic Publishers, 2004.
2. Surface Engineering of Metals: Principles, Equipment and Technology, 1st Edition - Tadeusz Burokowski, Tadeusz Wierzchon, CRC Press Inc, 1998.

Reference Books:

1. Advanced Techniques for Surface Engineering, 1st Edition - W. Gissler, and Herman A. Jehn, published by Kluwer Academic Publishers,1992.
2. Laser Material Processing, 4th Edition -William M. Steen and Jyotirmoy Mazumder, Published by Springer, 2010.

METAL FORMING LAB

III Year B.Tech. 6th -Sem

Course Objectives:

This lab course is designed to know

1. To know the behaviour of the materials under various types of loading.
2. Provide knowledge and experience in the measurement of various material properties.
3. To operate the various equipment like Erichson cupping, Rolling mill etc.., and analyze the process in them.

LIST OF EXPERIMENTS:

1. Determination of forming limit diagram
2. Kinetics of static recrystallization in a cold worked metal.
3. Growing of single crystals by Strain annealing technique.
4. Verification of Hall-Petch relation.
5. The work hardening and strain rate sensitivity of a metal.
6. The effect of plastic anisotropy on the deformation behaviour.
7. The effect of rolling variables on the mechanical properties of metals.
8. Forging operations in the production of a hook.
9. Ring compression test to determine the friction coefficient.
10. The flow pattern in plasticine clay when extruded through a die.
11. The defects produced in rolled and forged products.

Course Outcomes:

1. To know the behaviour of the materials under various types of loading.
2. Provide knowledge and experience in the measurement of various material properties.
3. Determine strain hardening exponent, effect of grain size and plastic anisotropy under various types of experiments/ practical conditions.
4. Determine the effect of process variables affecting various forming methods.
5. Work on forging, extrusion and rolling mills and analyze and interpret the outcome of the processes.
6. Prepare formal laboratory reports.

METAL JOINING LAB

III Year B.Tech. 6th -Sem

Course Objectives:

1. It also designed to make the student to understand and demonstrate the various types of

welding processes and its variables.
2. Understand and apply the principles of metal casting process and develop relation between input and output parameters.
3. To study the various modes of metal transfer that exists in welding processes.

LIST OF EXPERIMENTS:

1. Making of welded joints using conventional welding processes- arc welding.
2. Making of welded joints using conventional welding processes- gas welding.
3. Making of at least one joint using TIG Welding techniques of mild steel.
4. Making of at least one joint using MIG Welding techniques of mild steel.
5. Soldering
6. Arc welding of dissimilar metals
7. Microstructure study of HAZ
8. Testing of welded joints – Hardness survey and Tensile test
9. Microstructure study of welded joints
10. Inspection of welded joints by dye penetration, Magnetic methods and ultrasonic method.

Course Outcomes:

1. To identify welding process.
2. To analyse the HAZ after welding.
3. To prepare weld joints using different methods.
4. To test weld joints and study them.
5. To join different metals by soldering methods.
6. To prepare laboratory reports.

INTRODUCTION TO INSTRUMENTATION

IV year B.Tech. 7th -Sem

Course Objectives:

To have a knowledge of:

1. Electronic Instruments.
2. Pressure measurements.
3. Flow measurements.
4. Vibration, Viscosity and Humidity Level measurement.
5. Various analyzers.

Module -1

Electronic Instruments: CRO- Storage oscilloscope – Digital voltage meter (DVM) –Digital multi meter – XY Recorder, Strip chart recorder – Digital recording- Data logger – Introduction to virtual instrumentation.

Module -2

Pressure Measurements: Unit of Pressure – Manometers- Different types, - Elastic type pressure gauges – Bourdon tube – Bellows – Diaphragm – Elastic elements with LVDT and strain gauge – Capacitive type pressure gauge – Measurement of vacuum – McLeod gauge – Thermal conductivity gauge – Ionisation gauge.

Module -3

Flow Measurements: Flow meters – Variable head type flow meter – Orifice plate – Venture tube – Positive displacement flow meter: Nutating disc, Reciprocating piston, oval gear and helix type flow meter – Rota meter – Mass flow meters.

Module -4

Vibration, Viscosity, Humidity, Level Measurement: Mechanical type vibration measuring instruments – Seismic instruments as an accelerometer- Vibrometers – Viscosity – Saybolt viscometer. Humidity – Hot wire electro type hygro meter - Dew cell – Electrolysis type hygrometer.

Module -5

Analyzers: Dissolved Analyzer: Conductivity meter – pH meter – Dissolved oxygen analyzer – Sodium analyzer – Silica analyzer – Turbidity meter – Gas analyzer – NOx analyzer – H_2S analyzer – CO and CO_2 monitor, Dust & Smoke measurement.

Course Outcomes:

At the end of the course the student will be able to:

- **CO-1:** The knowledge gained on electronic, pressure, flow and vibration measurement willprovide a strong platform to understand the concepts on these subjects for further learning**.**
- **CO-2:** Comprehend various pressure measurements.
- **CO-3:** Make accuracy statements for various types of measurements.
- **CO-4:** Differentiate
- **CO-5:** To be able to describe the operation of instruments used for various gas, liquid and solidmaterials.
- **CO-6:** The knowledge gained on electronic, pressure, flow and vibration measurement willprovide a strong platform to understand the concepts on these subjects for further learning**.**

Course Outcome No	Statement	Knowledge Level (KL)
CO1	The knowledge gained on electronic, pressure, flow and vibration measurement will provide a strong platform to understand the concepts on these subjects for further learning**.**	K1
CO2	Comprehend various pressure measurements.	K3

CO3	Make accuracy statements for various types of measurements.	K1
CO4	Differentiate	K4
CO5	To be able to describe the operation of instruments used for various gas, liquid and solidmaterials.	K3
CO6	The knowledge gained on electronic, pressure, flow and vibration measurement will provide a strong platform to understand the concepts on these subjects for further learning.	K2

KL – Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1- Remember, K_2 – Understand, K_3 – Apply, K_4 – Analyze, K_5- Evaluate, K_6 – Create

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3			3				2	1			
CO2	2				1		1	3	3			
CO3	3		2	3				1	1			
CO4												
CO5												
CO6												
CO Average	2.66		2	3	1		1	2	1.66			

3 - High; 2 - Medium; 1 – Low

Text Books:

1. Alan S. Morrris. Principles of Measurement and Instrumentation, Prentice-Hall of India Pvt., Ltd. New Delhi, 1999.
2. Ernest O Doeblin. Measurement Systems Application & Design, Tata McGraw Hill Publishing Co., New. Delhi, 1999.

Reference Books:

1. Murthy, D.V.S. Transducers and Instrument and Instrumentation, Prentice Hall of India Pvt. Ltd. New Delhi.
2. Patranabir, D. Principle of Industrial Instrumentation, Tata McGraw Hill Publishing Co., New Delhi 1999.
3. Jain, R.K. Mechanical and Industrial Measurements, Khanna Publishing, New Delhi, 1999.
4. Liptak B.G. Instrumentation Engineers Hand Book (Measurement), Chilton Book Co., 1994.

ENVIRONMENTAL DEGRADATION OF MATERIALS

IV Year B.Tech. 7th -Sem

Pre-Requisites: Engineering Chemistry, Thermodynamics and Kinetics and Principles of Extractive Metallurgy.

Course Objectives:

1. Electrometallurgy principles in deposition winning and the efficiency of the bath to be discussed.
2. Testing methods are to be studied. Various ways in which corrosion takes place in metals/alloys together with corrosion protection methods and tests conducted are to be studied.
3. Able to use principles to understand, the prevention of corrosion.

Module -1

Electro chemical principles, Nernst equation, electrode potentials, Faradays laws. Polarization, passivity, environmental effects (oxygen, oxidizers, velocity, temperature, corrosive concentration, Galvanic coupling).

Module -2

Forms of corrosion, uniform corrosion, galvanic corrosion, EMF and Galvanic Series, Pitting corrosion, Crevice corrosion. Intergranular corrosion.

Module -3

Stress corrosion cracking: crack morphology, stress effects, environmental factors, metallurgical factors, Erosion corrosion: cavitation damage, fretting corrosion, hot corrosion.

Module -4

Corrosion prevention methods: Alteration of Environment (Inhibitors), Design, Coatings, cathodic and anodic protection. Material selection, Metallurgical aspects, Hydrogen damage (hydrogen blistering, Hydrogen embrittlement, Prevention), Electroplating.

Module -5

Corrosion testing methods: Immersion technique, Linear polarization, salt spray method, and Corrosion rate calculations.

Course Outcomes:

At the end of the course the student will be able to:

- **CO-1:** Outline the electrochemistry of the corrosion process.
- **CO-2:** Identify and analyze the “Eight Forms of Corrosion”.
- **CO-3:** Describe the effects of specific corrosion environments prevailing in the oil and gasindustry.
- **CO-4:** Select appropriate corrosion monitoring and control techniques.
- **CO-5:** To design for corrosion protection, minimization.
- **CO-6:** Review and select appropriate materials for corrosion resistant applications.

Course Outcome No	Statement	Knowledge Level (KL)
CO1	Outline the electrochemistry of the corrosion process.	K1
CO2	Identify and analyze the "Eight Forms of Corrosion".	K3
CO3	Describe the effects of specific corrosion environments prevailing in the oil and gasindustry.	K1
CO4	Select appropriate corrosion monitoring and control techniques.	K4
CO5	To design for corrosion protection, minimization.	K3
CO6	Review and select appropriate materials for corrosion resistant applications.	K2

KL – Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1- Remember, K_2 – Understand, K_3 – Apply, K_4 – Analyze, K_5- Evaluate, K_6 – Create

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3			3				2	1			
CO2	2				1		1	3	3			
CO3	3		2	3				1	1			
CO4												
CO5												
CO6												
CO Average	2.66		2	3	1		1	2	1.66			

3 - High; 2 - Medium; 1 – Low

Text Books:

1. Corrosion Engineering, 3rd Edition – Mars Fontana, published by McGraw Hill Education, 2017.
2. Electrometallurgy – William Blum.

Reference Books:

1. An Introduction to Electrometallurgy & Corrosion - Dr. R. Sharan and Satya Narain published by Standard Publishers Distributors, 2017.
2. Corrosion Engineering: Principles and Solved Problems, 1st Edition - Branko N. Popov published by Elsevier, 2015
3. Handbook of Corrosion Engineering, 2nd Edition - Pierre R. Roberge, published by McGraw-Hill Education, 2012.

NUCLEAR METALLURGY
(Elective – II)

IV Year B.Tech. 7th -Sem

Pre requisites: Nil

Course Objectives:

1. To explain and describe the basics of Nuclear technology and relevance of metallurgy to nuclear reactors.
2. To gain a working knowledge of extraction of nuclear metals like Uranium, Thorium, and Beryllium.
3. To understand principles of nucleation reactors and its safety.

Module -1

Elementary nuclear physics and chemistry: Structure of nucleus, radioactivity, binding energy: nuclear interaction; fission and fusion: nuclear reaction; energy release and chain reactions; neutron cross-section; multiplication and criticality concepts and factors.

Module -2

Mechanisms of moderation, radiation detection, radiation effects on fissile and non-fissile materials; radiation damage and radiation growth; thermal cycling; protection against radiations.

Module -3

Types of reactors and classification.

Considerations in selection and properties of common materials used as nuclear fuels, their physical and chemical properties; canning materials; coolants; control rods; reflectors shielding materials and Clad tubes

Module -4

Occurrence and general characteristics of nuclear minerals. Flow sheets of processing of nuclear minerals for the production of nuclear grade Uranium, Thorium, Beryllium and Zirconium with emphasis on basic scientific principles involved.

Module -5

Production and enrichment of uranium, Fabrication of fuel elements. Irradiated fuel processing for recovery of Plutonium.

Nuclear power production in India and its economics.

Course Outcomes:

At the end of the course the student will be able to:

- **CO-1:** Use fundamental concepts of physics and chemistry to know the basics of nuclear energy, understand the use of nuclear energy as a major source of energy.
- **CO-2:** Recognize the predominant mechanisms for materials failure in radiation environments, and understand the fundamentals of radiation damage events and

gain knowledge about thesafety measures and control.

- **CO-3:** Understand the guiding principles of reactor safety and report findings including recommendations for improvement.
- **CO-4:** Understand materials design issues in various reactor configurations and recognize the materials used in different types of reactor applications.
- **CO-5:** Understand the manufacturing processes and fabrications methods used for various materials used in reactors.
- **CO-6:** Work and communicate effectively in diverse and multi-disciplinary teams and be aware of modern professional, ethical, and societal issues as well as recognize the need for lifelong learning.

Course Outcome No	Statement	Knowledge Level (KL)
CO1	Use fundamental concepts of physics and chemistry to know the basics of nuclear energy, understand the use of nuclear energy as a major source of energy.	K1
CO2	Recognize the predominant mechanisms for materials failure in radiation environments, and understand the fundamentals of radiation damage events and gain knowledge about the safety measures and control.	K3
CO3	Understand the guiding principles of reactor safety and report findings including recommendations for improvement.	K1
CO4	Understand materials design issues in various reactor configurations and recognize the materials used in different types of reactor applications.	K4
CO5	Understand the manufacturing processes and fabrications methods used for various materials used in reactors.	K3
CO6	Work and communicate effectively in diverse and multi-disciplinary teams and be aware of modern professional, ethical, and societal issues as well as recognize the need for lifelong learning.	K2

KL – Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1- Remember, K_2 – Understand, K_3 – Apply, K_4 – Analyze, K_5- Evaluate, K_6 – Create

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3			3				2	1			
CO2	2				1		1	3	3			
CO3	3		2	3				1	1			
CO4												
CO5												
CO6												
CO Average	2.66		2	3	1		1	2	1.66			

3 - High; 2 - Medium; 1 – Low

Text Books:

1. Metallurgy in Nuclear Power Technology – J.C.Wright, published by Iliffe Books Ltd., 1962.
2. Nuclear Reactor Metallurgy – Wilkinson, WD and Murphy, WF. Published by D.Van Nostrand company, 1958.

Reference Books:

1. Symposium on Rare Materials - Indian Institute of Metals, 1957.
2. Nuclear Chemical Engineering, 2nd Edition - Manson Bendict and Thomas Pigford published by McGraw-Hill Education, 1981.
3. Nuclear Reactor General Metallurgy - B. N. Kuznetsov Sevryukov, B. Kuzmin, Chelishchev - Peace Publishers, 1965.

ELECTRONIC MATERIALS
(Elective - II)

IV Year B.Tech. 7th -Sem

Pre- Requisites: Nil

Course Objectives:

1. To become familiar with the science, synthesis, evaluation, and applications of electronic materials.
2. To know the manufacturing processes associated with use of electronic materials for devices.

Module -1

Electronic structure and its relevance in crystalline materials: Review of quantum mechanics: Electron as waves and particles; Wave-function; Electron as a plane-wave, Operators; Schrodinger Equation, Wave-vector (k); Energy of free-electron as a function of wave-vector k (ε - k diagram, a parabola), k-space; Density-of states [g(ε)]; Fermi-sphere, -energy, -surface, -temperature, and – velocity. Electrons in a solid following Fermi-Dirac distribution; DC conductivity in metals. Lattice; Bravais-Lattice; Wigner-Seitz cell; k-space: Reciprocal space; Reciprocal lattice and it's connection to its direct-lattice, Brillouin zone; Von-Lau condition of Bragg diffraction and boundaries of Brillouin-zone being the Bragg-Planes Electrons in a periodic-potential; Bloch Theorem, Kronig-Penny model; Origin of energy bands and band-gap; Free electron band diagram, Extended-, Periodic and reduced-zone representation for ε - k diagram; Allowed number of states in a band.

Module -2

Electron Dynamics: Group-velocity, electron dynamics from ε - k diagram and the concept of effective-mass and concept of holes; Conductivity in relation to band structure; Band structure of metals and semiconductors, and insulators; Band-overlap: why some metals show positive charge carriers in Hall-effect.

Module -3

Semiconductors and Magnetic Materials: Band diagrams, direct and indirect bandgap, applications of semiconductors; Effective-mass of electron in conduction-band and that of hole

in valence-band Intrinsic semiconductors: Fermi-level; Density-of-states near the edges of conduction and valence-band; Fermi-dirac statistics approximated by Maxwell-Boltzman; Intrinsic charge-carrier concentration, Law-of mass-action; Direct vs Indirect Semiconductors, Extrinsic-semiconductor: Hydrogen-model for rough estimate of the donor and acceptor energy level, n- and p-type semiconductors; Population of impurity levels in thermal equilibrium, charge-carrier concentration in n- and p- type semiconductors; Fermi-level, Degenerate and non-degenerate semiconductors, determination of dopant levels and mobility measurements Semiconductor Devices: p-n junction and solar cells; Bandgap engineering: Solid-state LEDs, Lasers and IR detectors. Orbital and spin - permanent magnetic moment of atoms, diamagnetism, paramagnetism, and Pauli-paramagnetism, Ferro, anti-ferro and ferri magnetism, Fe, Co and Ni and alloy additions, ferrites, magnetic hysteresis, exchange energy, magnetocrystalline energy, magnetorestriction; Highly correlated systems. Applications: Spintronics and memory devices Superconductors, Multiferroic materials.

Module -4

Ionic conductors and Dielectric materials: Ionic conduction – review of defect equilibrium and diffusion mechanisms; Theory of ionic conduction, conduction in glasses; Effect of stoichiometric and extrinsic defects on conduction, Applications in sensors and fuel cells.
Dielectric constants and polarization, linear dielectric materials, capacitors; Polarization mechanisms; Non-linear dielectrics, pyro-, piezo-, and ferro-electric properties, hysterisis and ferroelectric domains; Applications in sensors, actuators and memory devices.

Module -5

Manufacturing of Electronic Materials: Introduction to semiconductor manufacturing. History, overview of process flow, manufacturing goals. Scaling. Wafer manufacturing. Si ingot preparation. Poly to single crystal conversion. Czochralski vs. float zone method. IC device manufacturing overview. Thermal oxidation. Doping. Lithography. Etching and growth. Metallization and growth.

Course Outcomes:

At the end of the course the student will be able to:

- **CO-1:** Indicate and explain important scientific parameters associated with electronic materials.
- **CO-2:** Describe different semiconductors and their properties with examples.
- **CO-3:** Explain the features and functioning of several electronic devices.
- **CO-4:** Describe the manufacturing processes associated with electronic materials and devices.
- **CO-5:** Use simple band diagrams to understand the optical activity of a semiconductor.

Course Outcome No	Statement	Knowledge Level (KL)
CO1	Indicate and explain important scientific parameters associated with electronic materials.	K1
CO2	Describe different semiconductors and their properties with examples.	K3

CO3	Explain the features and functioning of several electronic devices.	K1
CO4	Describe the manufacturing processes associated with electronic materials and devices.	K4
CO5	Use simple band diagrams to understand the optical activity of a semiconductor.	K3

KL – Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1- Remember, K_2 – Understand, K_3 – Apply, K_4 – Analyze, K_5- Evaluate, K_6 – Create

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3			3				2	1			
CO2	2				1		1	3	3			
CO3	3		2	3				1	1			
CO4												
CO5												
CO6												
CO Average	2.66		2	3	1		1	2	1.66			

3 - High; 2 - Medium; 1 – Low

Text Books:

1. Electronic Properties of Materials: An Introduction for Engineers, Rolf E. Hummel, Springer Verlag, 1985
2. Physical Properties of Semiconductors, Charles M. Wolfe, Nick Holonyak and Gregory E. Stillman, Prentice Hall, 1989
3. Semiconductor Materials, Devices and Fabrication, Parasuraman Swaminathan, Wiley 2017

Reference Books:

1. Principles of Electronic Materials and Devices, S. O. Kasap, McGraw Hill Education, 2017.
2. Electronic Materials by Chelikowsky, James R., Franciosi, Alfonso (Eds.).
3. Electronic Materials and Processes Handbook by Charles Harper.

MECHANICAL METALLURGY

IV Year B.Tech. 7th -Sem

Course Objectives:

1. To gain an understanding of the response of various metals under the application of stress and/or temperature.
2. To build necessary theoretical back ground of the role of lattice defects in governing both elastic

and plastic properties of metals will be discussed.

3. Obtain a working knowledge of various hardness testing machines BHN, VHN, RHN.
4. Obtain a working knowledge of creep and fatigue and analysis of data.

Module -1

Metallurgical fundamentals: Defects in crystalline materials – Point defects and line defects. The concept of dislocations, edge dislocation and screw dislocation. Slip and twinning. Interaction between dislocations, sessile dislocation, glissile dislocation, energy of a dislocation, dislocation climb, Jogs, forces on dislocations. Frank Reed source, Critical resolved shear stress.

Module -2

Hardness Test: Brinell, Vickers, Rockwell, Microhardness test, relationship between hardness and other mechanical properties, Nanoindentation.

The Tension Test: Engineering stress-strain and True stress-strain curve. Tensile properties, conditions for necking, effect of temperature and strain rate on tensile properties.

Elastic and in-elastic action and properties in compression test.

The Impact Test: Notched bar impact test and its significance, Charpy and Izod Tests, fracture toughness testing - COD and CTOD tests, significance of transition temperature curve, metallurgical factors affecting on transition temperature, temper embrittlement.

Module -3

Fracture: Elementary theories of fracture, Griffith's theory of brittle fracture, ductile fracture, notch sensitivity. Strain-Energy release rate, Stress Intensity Factor, Fracture Toughness and design, K_{IC} Plane-Strain Toughness testing, plasticity corrections, J-Integral.

Module -4

Fatigue Test: Introduction, Stress cycles, S-N Curve, mechanism of fatigue failure, effect of mean stress, stress concentration, size, surface condition and environments on fatigue. Effect of metallurgical variables on fatigue. Low-cycle fatigue. High-cycle fatigue and thermal fatigue.

Module -5

Creep and Stress Rupture: Introduction, The creep curve, Stress-rupture test, structural changes during creep, mechanism of creep deformation, theories of creep. Fracture at elevated temperature, effect of metallurgical variables on creep.

Course Outcomes:

At the end of the course the student will be able to:

- **CO-1:** Interpret the effect of crystalline defects on the behavior of metals.
- **CO-2:** Can conduct hardness, Impact test and interpret COD, CTOD and DBTT diagrams.
- **CO-3:** Determine the appropriate test for analysis of tensile and compression properties ofmaterials.

- **CO-4:** Can design creep and fatigue resistant materials.
- **CO-5:** Assess and describe the mechanism leading failure of a given material.
- **CO-6:** Solve numerical problems and gain of knowledge of how to incorporate material strength limitation into engineering design.

Course Outcome No	Statement	Knowledge Level (KL)
CO1	Interpret the effect of crystalline defects on the behavior of metals.	K1
CO2	Can conduct hardness, Impact test and interpret COD, CTOD and DBTT diagrams.	K3
CO3	Determine the appropriate test for analysis of tensile and compression properties ofmaterials.	K1
CO4	Can design creep and fatigue resistant materials.	K4
CO5	Assess and describe the mechanism leading failure of a given material.	K3
CO6	Solve numerical problems and gain of knowledge of how to incorporate material strength limitation into engineering design.	K3

KL – Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1- Remember, K_2 – Understand, K_3 – Apply, K_4 – Analyze, K_5- Evaluate, K_6 – Create

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3			3				2	1			
CO2	2				1		1	3	3			
CO3	3		2	3				1	1			
CO4												
CO5												
CO6												
CO Average	2.66		2	3	1		1	2	1.66			

3 - High; 2 - Medium; 1 – Low

Text Books:

1. Mechanical Metallurgy – G. E. Dieter, 3rd edition, published by McGraw Hill Education, 2017.
2. Mechanical behavior of material - Thomas H. Courtney, Published by Waveland Pr Inc, 2005.

Reference Books:

1. Engineering Materials Science – Cedric William Richards, published by Literary Licensing, LLC, 2012.

2. Mechanical behavior, 3rd Edition - Wayne Hayden, William G. Moffatt, John Wulff published by John wiley and Sons, Inc, 1974.
3. Mechanical Metallurgy – White & Lemay.

TESTING OF MATERIALS
(Elective – III)

IV B.Tech. Met. Engg. 7th -Semester

Pre-requisites: Nil

Course Objectives:

1. To gain an understanding of the response of various metals under the application of stress and/or temperature.
2. Obtain a working knowledge of various hardness testing machines BHN, VHN, RHN
3. Obtain a working knowledge of creep and fatigue testing methods and analysis of data.
4. To get an exposure to NDT techniques for detection of various types of flaws.

Module -1

Introduction, Importance of testing.
Hardness Test: Methods of hardness testing – Brinell, Vickers, Rockwell hardness tests. Tensile Test: Engineering stress-strain and True stress-strain curves. Tensile properties, conditions for necking. Stress-Strain diagrams for Steel, Aluminum and Cast Iron.

Module -2

Impact Test: Notched bar impact test and its significance, Charpy and Izod Tests, fracture toughness testing - COD and CTOD tests, significance of transition temperature curve.

Module -3

Fatigue Test: Introduction, Stress cycles, S-N Curve, Effect of mean stress, mechanism of fatigue failure, effect of stress concentration, size, surface condition and environments on fatigue.

Module -4

Creep and Stress Rupture: Introduction, The creep curve, Stress-rupture test, structural changes during creep, mechanism of creep deformation, theories of creep. Fracture at elevated temperature.

Module -5

NDT: Principle, operation, advantages and limitations of Liquid Penetrant, Magnetic Particle, Radiography and Ultrasonic tests.

Text Books:

1. Mechanical Metallurgy, 3rd Edition – George E. Dieter, published by Mc Graw Hill Education, 2017.
2. Testing of Metallic Materials, 2nd Edition - A.V.K. Suryanarayana, published by BSP Books

Private Limited, 2018.

Reference Books:

1. Testing of Metals - Alok Nayar, published by Tata Mc Graw Hill, 2005.
2. Mechanical Behaviour and Testing of Materials, 1st edition – A.K. Bhargava and C.P. Sharma published by PHI Learning, 2011.

Course Outcomes:

At the end of the course the student will be able to:

1. Understand and interpret the results of various hardness tests and impact tests.
2. Evaluate various tensile properties of ferrous and non-ferrous metals and solve problems related to the tensile tests.
3. Analyze the modes of failure occurring due to fatigue and suggest remedial measures.
4. Analyze the methods of failure of materials at high temperature by creep and stress rupture and the mechanisms responsible for fracture.
5. Determine appropriate tests to be employed to determine the given mechanical properties using both destructive and non-destructive techniques.
6. Knowledge of various testing methods based on destructive & non destructive techniques and their importance in enhancing service life of the component.

CORROSION PROCESS AND CONTROL
(Elective – III)

IV B.Tech. Met. Engg. 7th -Semester

Pre-Requisites: Nil

Course Objectives:

1. To list out various atmospheres responsible for corrosion and understand the various corrosion combating techniques.
2. To determine corrosion rate/ resistance of metals and alloys.
3. To demonstrate electrometallurgy principles in deposition winning and the efficiency of the bath.
4. To explain corrosion protection methods and tests.

Module -1

Introduction, Electro Chemistry principles, Corrosion, Introduction and Definition, electrochemical reactions, Polarization, passivity, environmental effects (oxygen, oxidizers, velocity, temperature, corrosive concentration, Galvanic coupling).

Module -2

Forms of corrosion, uniform corrosion, Two metal corrosion: Sacrificial anode, EMF and Galvanic Series, Environmental effects, Pitting corrosion: Pit shape and growth, Autocatalytic Nature of pitting, Crevice corrosion.

Module -3

Intergranular corrosion: Sensitization, weld decay, Knife-Line attack, Stress corrosion cracking: crack morphology, stress effects, environmental factors, metallurgical factors, Erosion corrosion: cavitation damage, fretting corrosion, Corrosion fatigue.

Module -4

Corrosion prevention methods: Alteration of Environment (Inhibitors), Design, Coatings, cathodic and anodic protection. Material selection, Metallurgical aspects, Hydrogen damage (hydrogen blistering, Hydrogen embrittlement, Prevention).

Module -5

Modern theory and applications of corrosion: Introduction, free energy, cell potentials, emf series, applications of thermodynamics to corrosion, Corrosion rate expressions and measurements, corrosion testing.

Course Outcomes:

At the end of the course the student will be able to:

- **CO-1:** Able to interpret electro chemical phenomenon.
- **CO-2:** Can explain different types of corrosion, their causes, effect and able to identify thedifferent remedial measures to be taken.
- **CO-3:** Able to design corrosion resistant structures and materials.
- **CO-4:** Determine the thermodynamic causes of corrosion.
- **CO-5:** Conduct corrosion tests and able to quantify the corrosion processes.
- **CO-6:** Able to graphically represent and interpret Eh-pH, pourbiax extrapolation techniques.

Course Outcome No	Statement	Knowledge Level (KL)
CO1	Able to interpret electro chemical phenomenon.	K1
CO2	Can explain different types of corrosion, their causes, effect and able to identify thedifferent remedial measures to be taken.	K3
CO3	Able to design corrosion resistant structures and materials.	K1
CO4	Determine the thermodynamic causes of corrosion.	K4
CO5	Conduct corrosion tests and able to quantify the corrosion processes.	K3
CO6	Able to graphically represent and interpret Eh-pH, pourbiax extrapolation techniques.	K3

KL – Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1- Remember, K_2 – Understand, K_3 – Apply, K_4 – Analyze, K_5- Evaluate, K_6 – Create

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12

CO1	3			3				2	1			
CO2	2				1		1	3	3			
CO3	3		2	3				1	1			
CO4												
CO5												
CO6												
CO Average	2.66		2	3	1		1	2	1.66			

3 - High; 2 - Medium; 1 – Low

Text Books:

1. Corrosion Engineering, M. G. Fontana, 3rd edition, McGraw-Hill, 1985.
2. Corrosion and Corrosion Control, H. H. Uhlig, Wiley, 1985.

Reference Books:

1. Theory of Corrosion and Protection of Metals, N. D. Tomashov, Macmillan, 1967.
2. Introduction to Electrometallurgy & Corrosion by Sharan – Narayan.
3. Corrosion Engineering 1st Edition Principles and Solved Problems by Branko Popov.
4. Handbook of Corrosion Engineering, Second Edition by: Pierre R. Roberge, Ph.D.

ENVIRONMENTAL DEGRADATION OF MATERIALS LAB

IV Year B.Tech. 7th -Sem

Pre-Requisites: **NIL**

Course Objectives:

1. This lab course is designed to conduct the experiments on electro deposition, verification of Faraday's laws and evaluation of factors affecting on corrosion.
2. To provide understanding of basic electro kinetics.
3. To provide basic knowledge on current efficiency for various electrolytes and electro metallurgy processes.

List of Experiments:

1. EMF series
2. Electroplating of copper.
3. Anodizing.
4. Electroplating of Nickel.
5. Electroplating of chromium.
6. Electroplating of Zinc.
7. Galvanic corrosion.

8. Pitting corrosion.
9. Uniform corrosion acid environments.
10. Uniform corrosion basic environments.
11. Corrosion rate measurement in acid environments.
12. Corrosion rate measurements in basic environment.

Course Outcomes:

Through this laboratory practice, the student will be able:

1. To judge the process variables like current efficiency, current density.
2. To obtain desired electro deposition.
3. Hands on experience on equipment designed for evaluation of corrosion studies.

MECHANICAL METALLURGY LAB

IV Year B.Tech. 7th - Sem

Pre-Requisites: Mechanical Metallurgy

Course Objectives:

Students will be able:

1. Demonstrate skill in using different hardness testing machines.
2. Explain the rationale for using particular loads in testing hardness and tensile properties of materials.
3. Knowledge of the standard specimens dimensions and determining toughness of materials by impact test.
4. Become aware of working principle and use of various Non Destructive Tests.

List of Experiments:

1. Determine the hardness of ferrous and non-ferrous samples using Brinell hardness.
2. Determine the hardness of ferrous and non-ferrous samples using Rockwell hardness.
3. Tension test:
    a. Determine the Tensile properties of ductile ferrous materials.
    b. Determine the Tensile properties of ductile non-ferrous materials.
4. Determine the Compression properties of brittle materials.
5. To determine the Toughness of the given material by Charpy and Izod (V & U Groove notch).
6. Determination the variation of formability of the given various thickness materials by Erichson cupping test.
7. Liquid penetrant Test: To detect the surface flaws in a given materials by dye penetrant.
8. To detect the surface flaws in steel by fluorescent penetrant method.
9. Magnetic flaw detector: To inspect a given material for cracks.
10. Ultrasonic flaw detection: To inspect a given material for locating cracks.

Course Outcomes:

After completing the course, the student will be able:

1. Explain the methods of destructive testing (Hardness testing, Tensile testing, Impact and cupping tests) and non destructive testing (LPT, MPT and UT).

2. Analyze, interpret and present the observation from the tests conducted.
3. Identify the reasons for failure through Non Destructive Examination.
4. Can prepare formal laboratory reports describing the experimental and the results obtained.
5. Solve material problems associated by proper testing.

SOLIDIFICATION PROCESSING
(Elective - IV)

IV Year B.Tech. 8th -Sem

Pre-Requisites : Physical Metallurgy and Material Processing-I

Course Objectives :

1. To inculcate the metallurgical aspects during solidification of metal and alloys.
2. To impart knowledge about solidification of casting with detail emphasis on calculation of gating/riser system.
3. To impart knowledge about solidification behaviour during welding and effect of microstructure in HAZ.

Module -1
Principles of solidification: Nucleation and growth of pure metals and alloys, Cooling curves, heat transfer associated in nucleation and growth, eutectic solidification; Homogeneous and Heterogeneous nucleation.

Module -2
Solidification of ingots and castings: formation of plane front columnar, equiaxed and dendritic structures, Effect of composition, moulding materials and cooling rate on solidification pattern.

Module -3
Segregation and shrinkage phenomena in castings, calculation of solidification time for casting, heat transfer calculations in metal casting, principles of chill design.

Module -4
Heat transfer in weldments, dissipation of welding heat, cooling rates, weld metal cooling curves, peak temperature, calculating width of heat affected zones, solidification rate and effects of heat input.

Module -5
Heat conduction with and without phase change by finite element method, finite volume method and finite differences methods.

Course Outcomes:

At the end of the course the student will be able to:

- **CO-1:** Explain the principles and practice of directional solidification.

- **CO-2:** Describe the procedures used for controlling porosity and shrinkage during solidificationprocessing.
- **CO-3:** List out the microstructural differences between cast and wrought metallic alloy products.
- **CO-4:** Knowledge about the microstructural mechanisms associated with metals joiningoperations including heat affected zones.
- **CO-5:** Explain the principles and practice of directional solidification.
- **CO-6:** Describe the procedures used for controlling porosity and shrinkage during solidificationprocessing.

Course Outcome No	Statement	Knowledge Level (KL)
CO1	Explain the principles and practice of directional solidification.	K1
CO2	Describe the procedures used for controlling porosity and shrinkage during solidificationprocessing.	K3
CO3	List out the microstructural differences between cast and wrought metallic alloy products.	K1
CO4	Knowledge about the microstructural mechanisms associated with metals joiningoperations including heat affected zones.	K4
CO5	Explain the principles and practice of directional solidification.	K3
CO6	Describe the procedures used for controlling porosity and shrinkage during solidificationprocessing.	K3

KL – Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1- Remember, K_2 – Understand, K_3 – Apply, K_4 – Analyze, K_5- Evaluate, K_6 – Create

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3			3				2	1			
CO2	2				1		1	3	3			
CO3	3		2	3				1	1			
CO4												
CO5												
CO6												
CO Average	2.66		2	3	1		1	2	1.66			

3 - High; 2 - Medium; 1 – Low

Text Books:

1. Physics of Welding – J. F. Lancaster, Pergamon press, 1986.
2. Principles of Metal Casting, 2nd Edition - Richard W. Heine, Carl R. Loper, Philip C. Rosenthal, published by McGraw Hill Higher Education1976.

Reference Books:

1. Fundamentals of Solidification, 4th Edition - W. Kurz and D.J. Fisher, published by CRC Press, 1998.
2. Castings, 2nd Edition - John Campbell, published by Butterworth Heinemann, 2003.
3. Science and Engineering of Casting Solification, 2nd Edition - Doru Micheal stefanescu, published by Springer, 2009.
4. Solidification and Casting - Davies, Graeme John, Applied science publishers Ltd., 1973
5. Solidification Processing - M.C. Flemings, McGraw-Hill, N.Y., 1974
6. Solidification of Casting; Ruddle, R.W., Institute of Metals, 1957

NON METALLIC MATERIALS
(Elective - IV)

IV Year B.Tech. 8th -Sem

Pre-Requisites: Nil

Course Objectives:

1. To introduce the student to the range of non-metallic materials available for engineering.
2. To understand the classification and significance of nonmetallic materials to apply them in Industries.
3. To get an exposure to the techniques associated with the synthesis, processing and characterization of these materials.
4. To become aware of the applications where these materials are preferred.

Module -1

Definition and classification of materials, comparison of properties of metals and nonmetallic materials. Nature of bonding.

Module -2

Ceramics: Structure, defects. Ionic and semiconducting behavior. Processing techniques. Glasses and glass-ceramics, glass fibres. Structural ceramics: fracture toughness, toughening mechanisms. Special ceramics: Electro-optic, dielectric, ferroelectric, piezoelectric, magnetic, superconducting, laser and dilute magnetic and bio-ceramics.

Module -3

Polymers: Structure, properties and applications of thermoplastics and thermosets.
Conducting and biopolymers.

Module -4

Composites: Introduction, classification, and applications of composite materials. Manufacturing of Polymer matrix, metal matrix, and ceramic matrix composites.

Module -5

Textiles. Adhesives, and Foams: Introduction, classification and applications of textile

materials. Structure of Adhesives and their applications. Classification and applications of foam materials, Manufacturing methods of industrially important adhesives and foams.

Course Outcomes:

At the end of the course the student will be able to:

- **CO-1:** List the prominent non-metallic materials available for engineering applications.
- **CO-2:** Indicate the synthesis and processing steps associated with non-metallic materials.
- **CO-3:** Indicate the structure property relations in non-metallic materials.
- **CO-4:** Understand the behavior of each non-metallic material in detail.
- **CO-5:** Indicate the uses for which non-metallic materials are preferred.
- **CO-6:** Explain the manufacturing methods of industrially important adhesives and foams.

Course Outcome No	Statement	Knowledge Level (KL)
CO1	List the prominent non-metallic materials available for engineering applications.	K1
CO2	Indicate the synthesis and processing steps associated with non-metallic materials.	K3
CO3	Indicate the structure property relations in non-metallic materials.	K1
CO4	Understand the behavior of each non-metallic material in detail.	K4
CO5	Indicate the uses for which non-metallic materials are preferred.	K3
CO6	Explain the manufacturing methods of industrially important adhesives and foams.	K3

KL – Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1- Remember, K_2 – Understand, K_3 – Apply, K_4 – Analyze, K_5- Evaluate, K_6 – Create

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3			3				2	1			
CO2	2				1		1	3	3			
CO3	3		2	3				1	1			
CO4												
CO5												
CO6												
CO Average	2.66		2	3	1		1	2	1.66			

3 - High; 2 - Medium; 1 – Low

Text Books:

1. Textbook of Polymer Science 3rd Edition - Fred W. Billmeyer, Published by Wiley 2007.
2. Introduction to Ceramics, 2nd Edition - W. David Kingery, H.K. Bowen, Donald R. Uhlmann, published by Wiley India Pvt Limited, 2012.

Reference Books:

1. Composite Materials: Science and Engineering, 4th Edition - Krishan K. Chawla, Springer, 2019.
2. Principles of Materials Science and Engineering, 3rd Edition - William Smith, Published by McGraw-Hill Education, 1995.
3. Materials Science and Engineering, 6th Edition - V. Raghavan, published by Prentice Hall India Learning Private Limited, 2015.

FUNCTIONAL MATERIALS
(Elective – IV)

IV Year B.Tech. 8th -Semester

Pre-Requisites: Nil

Course Objectives:

1. To introduce the student to functional materials and the science behind the performance of the functional materials.
2. To enable the student to understand the applications of functional materials.
3. To study about semiconductors, dielectrics, Piezo, Ferro electric and smart materials.

Module -1

Characteristics and types of functional materials. Crystal structure and Properties. Effect of size on properties, effect of interfaces on properties. Magnetic materials and storage applications.

Module -2

High Temperature Behaviour of Amorphous and Nanocrystalline Soft Magnetic Materials Magnetic storage devices store data using a combination of magnetic fields and binary data, Band structure, Semiconductor devices – Theory, examples and applications of Optically active materials.

Module -3

Basics of semiconductor electrical properties, operation of the semiconductor devices. Eg: Band structure, Diode, MOS device capacitor, MOS transistor structure and operation, Transistor formation and Transistor isolation.

Module -4

Dielectrics, Piezo and ferroelectric materials: Introduction, properties, applications. Recent developments in advanced dielectric, piezoelectric and ferroelectric materials. High strain high

performance piezo- and ferroelectric single crystals; Electric field-induced effects and domain engineering; Morphotropic phase boundary related phenomena; High power piezoelectric and microwave dielectric materials; Nanoscale piezo- and ferroelectrics.

Module -5

Smart materials: Introduction, definition, applications, factors affecting properties of smart materials. Applications in electronic, communication, aerospace, automotive, energy industries.

Course Outcomes:

At the end of the course the student will be able to:

- **CO-1:** Indicate the various types of functional materials.
- **CO-2:** Explain the principle of operation of the functional materials.
- **CO-3:** Indicate the applications of the functional materials.
- **CO-4:** Judge the factors that affect the interface and size on the properties of functional materials.
- **CO-5:** Identify the applications of functional materials in advance and modern systems.
- **CO-6:** Indicate the various types of functional materials.

Course Outcome No	Statement	Knowledge Level (KL)
CO1	Indicate the various types of functional materials.	K1
CO2	Explain the principle of operation of the functional materials.	K3
CO3	Indicate the applications of the functional materials.	K1
CO4	Judge the factors that affect the interface and size on the properties of functional materials.	K4
CO5	Identify the applications of functional materials in advance and modern systems.	K3
CO6	Indicate the various types of functional materials.	K3

KL – Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1- Remember, K_2 – Understand, K_3 – Apply, K_4 – Analyze, K_5- Evaluate, K_6 – Create

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3			3				2	1			
CO2	2				1		1	3	3			
CO3	3		2	3				1	1			
CO4												
CO5												
CO6												
CO	2.66		2	3	1		1	2	1.66			

Average												

3 - High; 2 - Medium; 1 – Low

Text Books:

1. Functional Materials: Electrical, Dielectric, Electromagnetic, Optical and Magnetic applications, - Deborah D L Chung, World Scientific Publishing, 2010.
2. Advanced Functional Materials (Advanced Material Series), 1st Edition – Ashutosh Tiwari, Lokman Uzun, published by Wiley-Scrivener, 2015.

Reference Books:

1. Functional Materials: Preparation, Processing and Applications, 1st Edition – by S. Banerjee, A.K.Tyagi, published by Elsevier, 2011.
2. Advanced Functional Materials by Hee – Gweon Woo, Hong Li, published by Springer, 2011.
3. Functional Materials: Properties, Performance and Evaluation, 1st Edition - Ewa Klodzinska published by Apple Academic Press, 2015.

ALLOY STEELS
(Elective - IV)

IV B.Tech. Met. Engg. 8th -Semester

Pre-Requisites: Nil

Course Objectives:

This course deals with:

1. Describe the physical metallurgy of steels and alloy steels.
2. Explain the microstructure and properties of steels and alloy steels.
3. Make judgments on microstructural evolution and properties developed in alloy steels.

Module -1

Classification of Steels. Advantages and limitations of Plain carbon steels. Alloy steels classification, purpose and general effects of alloy elements in steels. Cold forming steels, High strength packing steels; HSLA steels.

Module -2

Medium - High carbon ferrite-pearlite steels, Bainitic steels, Low-carbon bainitic steels requirements, development and choice of alloying elements, Mechanical properties, microstructure and impact properties, High-Carbon bainitic steels.

Module -3

Ultra-high strength steels: Classification and applications. Cryogenic steels, Thermo-mechanical treatments, maraging steels.

Module -4

Stainless steels: Classification, Composition, role of alloying elements, Heat treatment, microstructure and applications. Nitrogen steels and dual phase steels

Module -5

Tool steels and Heat resistant steels: Classification, Composition, role of alloying elements, Heat treatment, microstructure and applications.

Course Outcomes:

At the end of the course the student will be able to:

- **CO-1:** Able to classify plain carbon steels, alloy steels and differentiate the steels and appreciate the role of alloy elements in steels and how to modify the structures to get the desired properties in steels.
- **CO-2:** Know the importance of structure - property correlation study in HSLA, Ultra high strengthsteels etc.., and their suitable applications.
- **CO-3:** Analyze the importance of composition, heat treatment and microstructure effects on properties and uses of stainless steels.
- **CO-4:** Analyze the importance of composition, heat treatment and microstructure effects on properties and uses of tool steels and heat resistant steels.
- **CO-5:** Able to apply the knowledge gained on microstructural evolution and its stability to optimize the processing routes for specific applications.
- **CO-6:** Able to classify plain carbon steels, alloy steels and differentiate the steels and appreciate the role of alloy elements in steels and how to modify the structures to get the desired properties in steels.

Course Outcome No	Statement	Knowledge Level (KL)
CO1	Able to classify plain carbon steels, alloy steels and differentiate the steels and appreciate the role of alloy elements in steels and how to modify the structures to get the desired properties in steels.	K1
CO2	Know the importance of structure - property correlation study in HSLA, Ultra high strengthsteels etc.., and their suitable applications.	K3
CO3	Analyze the importance of composition, heat treatment and microstructure effects on properties and uses of stainless steels.	K1
CO4	Analyze the importance of composition, heat treatment and microstructure effects on properties and uses of tool steels and heat resistant steels.	K4
CO5	Able to apply the knowledge gained on microstructural evolution and its stability to optimize the processing routes for specific applications.	K3
CO6	Able to classify plain carbon steels, alloy steels and differentiate the steels and appreciate the role of alloy elements in steels and how to modify the structures to get the desired properties in steels.	K3

KL – Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1- Remember, K_2 – Understand, K_3 – Apply, K_4 – Analyze, K_5- Evaluate, K_6 – Create

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3			3				2	1			
CO2	2				1		1	3	3			
CO3	3		2	3				1	1			
CO4												
CO5												
CO6												
CO Average	2.66		2	3	1		1	2	1.66			

3 - High; 2 - Medium; 1 – Low

Text Books:

1. Physical Metallurgy and the Design of steels - F. B. Pickering, Applied Science publisher, London, 1978.
2. The physical Metallurgy of steels: William C. Leslie, Hempisphere Publishers Corporation, 1981.

Reference Books:

1. Alloys Steels – Wilson.
2. Heat Treatment of steels, 2nd Edition – Rajan & Sharma, PHI publications, 2011.

BIO MATERIALS

IV Year B.Tech. 8th -Sem

Pre- Requisites: Nil

Course Objectives:

1. To introduce the student to the range of biomaterials and the science and engineering of biomaterials.
2. To understand constraints associated with the use of biomaterials.
3. To study various real time applications of bio materials.

Module -1

Introduction to basic concepts of Materials Science, Salient properties of important material classes. Property requirement of biomaterials. Concept of biocompatibility. Structure and properties of biological cells & tissues. Cell-material interactions and foreign body response.

Module -2

Assessment of biocompatibility of biomaterials. In vitro biochemical assays (cellular adhesion,

cellular viability using MTT, osteogenic differentiation using ALP assay; Biomnuneralisation using Osteocalcin assay). In vivo testing and histocompatibility assessment. Genotoxicity assessment (Physical damage to DNA by biomaterial eluates).

Module -3

Important bio-metallic alloys: Ti-based, stainless steels, Co-Cr-Mo alloys. Bio-inert, Bioactive and bioresorbable ceramics. Biocompatibility of Alumina & Carbon Nanotube Reinforced Hydroxyapatite. Glass -ceramics for dental restoration applications.

Module -4

Processing and properties of different bio-ceramic materials with emphasize on hydroxyapatite. Synthesis of biocompatible coatings on structural implant materials. Plasma spraying of carbon nanotube reinforced hydroxyapatite on Ti-6Al-4V substrate, in-vitro cytocompatibility. Microstructure and properties of glass-ceramics. Biodegradable polymers.

Module -5

External field and cell – material interaction, Tissue Engineering and Wound healing. Design concept of developing new materials for bio-implant applications.

Course Outcomes:

At the end of the course the student will be able to:

- **CO-1:** Explain the types of biomaterials and their relative advantages and disadvantages.
- **CO-2:** Indicate the constraints placed on the use of materials in biological environments.
- **CO-3:** Explain the characterization of materials from the perspective of application as abiomaterial.
- **CO-4:** Explain the factors affecting the bio compatibility of materials.
- **CO-5:** Develop and design new advanced materials.
- **CO-6:** Develop biodegradable materials for sensitive applications.

Course Outcome No	Statement	Knowledge Level (KL)
CO1	Explain the types of biomaterials and their relative advantages and disadvantages.	K1
CO2	Indicate the constraints placed on the use of materials in biological environments.	K3
CO3	Explain the characterization of materials from the perspective of application as abiomaterial.	K1
CO4	Explain the factors affecting the bio compatibility of materials.	K4
CO5	Develop and design new advanced materials.	K3
CO6	Develop biodegradable materials for sensitive applications.	K3

KL – Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1- Remember, K_2 – Understand, K_3 – Apply, K_4 – Analyze, K_5- Evaluate, K_6 – Create

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3			3				2	1			
CO2	2				1		1	3	3			
CO3	3		2	3				1	1			
CO4												
CO5												
CO6												
CO Average	2.66		2	3	1		1	2	1.66			

3 - High; 2 - Medium; 1 – Low

Text Books:

1. Introduction to Biomaterials: Basic Theory with Engineering Applications, 1st Edition - C. Mauli Agrawal, Joo L. Ong, Mark R. Appleford and Gopinath Mani, published by Cambridge University Press, 2013.
2. Biomaterials Science: An introduction to Materials in Medicine, 3rd Edition - Edited by Buddy D. Ratner, Allan S. Hoffman, Frederick J. Schoen and Jack E. Lemons - Academic Press, 2012.

Reference Books:

1. Comprehensive Structural Interity, Vol.9: Bioengineering Editors: Mithe, Ritchie and Karihalo, Elsevier Academic Press, 2003.
2. Biomaterials Science and Biocompatability, 1st Edition - Fredrick H. Silver and David L. Christiansen, published by Springer, 2012.
3. Biological Performance of Materials: Fundamentals of Biocompatibility, 3rd Edition - Jonathan Black, published by Marcel Dekker, Inc., 1992.
4. Basic Cell Culture: A Practical Approach - Edited by J.M. Davis, published by Oxford University Press, 1995.

TRANSPORT PHENOMENA

IV Year B.Tech. 8th -Sem

Pre-Requisites: Nil

Course Objectives:

1. This course will introduce the concepts of fluid flow, heat transfer and mass transfer with behavior and processing of engineering materials as the focus.

2. To learn Newton's law of viscosity, Navier-strokes equation, Darcy's law and their applications.
3. To study the methods of diffusion and their applications.

Module -1

Balance of quantities using elemental volume approach, continuity equation Newton's law of viscosity.

Module -2

Navier-Stokes equation, laminar flow problems, exact solutions in rectangular, cylindrical and spherical coordinate systems.

Module -3

Friction factors, correlations for turbulent regime, Darcy's law, flow through porous media, Fundamentals of heat conduction, convection, radiation and their combined effect.

Module -4

Steady and unsteady heat transfer, exact analytical solutions, correlations for conjugate heat transfer. Coupled phenomena in transport, Non-dimensional numbers and their correlations of different regimes and analogies.

Module -5

Diffusion and its application in solid state, convective mass transfer, unsteady diffusion in finite and infinite bodies, diffusion and chemical reactions.

Course Outcomes:

At the end of the course the student will be able to:

- **CO-1:** Demonstrate and understanding of heat transfer, fluid flow and mass transfer.
- **CO-2:** Pose a problem in transport phenomena as a balance equation.
- **CO-3:** Make suitable assumptions to make the problem a well-defined one.
- **CO-4:** Identify suitable geometry and boundary conditions for the problem.
- **CO-5:** Solve simple partial differential equations relevant to transport phenomena.
- **CO-6:** Plot different parameters and interpret the solutions.

Course Outcome No	Statement	Knowledge Level (KL)
CO1	Demonstrate and understanding of heat transfer, fluid flow and mass transfer.	K1
CO2	Pose a problem in transport phenomena as a balance equation.	K3
CO3	Make suitable assumptions to make the problem a well-defined one.	K1
CO4	Identify suitable geometry and boundary conditions for the problem.	K4

CO5	Solve simple partial differential equations relevant to transport phenomena.	K3
CO6	Plot different parameters and interpret the solutions.	K3

KL – Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1- Remember, K_2 – Understand, K_3 – Apply, K_4 – Analyze, K_5- Evaluate, K_6 – Create

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3			3				2	1			
CO2	2				1		1	3	3			
CO3	3		2	3				1	1			
CO4												
CO5												
CO6												
CO Average	2.66		2	3	1		1	2	1.66			

3 - High; 2 - Medium; 1 – Low

Text Books:

1. Transport phenomena, 2nd Edition- R. Byron Bird, Warren E. Stewart and Edwin N. Lightfoot, published by John Wiley & Sons, 2006.
2. Fundamentals of Momentum, Heat and Mass Transfer, 5th Edition - Welty, Wicks Wilson, Rorrer published by John Wiley & Sons, 2008.

Reference Books:

1. Transport Phenomena in Materials Processing - D.R. Poirier and G.H. Geiger, published by John Wiley & Sons, 2010.
2. Introduction to Fluid Mechanics, 5th Edition – Alan T. McDonald, Fox, Robert W Fox, John Wiley & Sons, 2002.

HIGH TEMPERATURE MATERIALS

IV B.Tech. Met. Engg. 8th -Semester

Pre-Requisites: Nil

Course objectives:

1. To learn and design material's microstructure for high temperature applications.
2. To learn scientific issues related to high temperature such as creep, oxidation and material

degradation.

3. To study the properties which improve high temperature resistance.

Module -1

Creep, Types of Creep, Testing methods, Creep data presentation, Creep Curve and stages of creep, Mechanisms of Creep and creep resistant steels.

Module -2

Fatigue, thermal fatigue, ageing, structural changes, material damage, crack propagation, damage mechanics, life time analysis, Creep-Fatigue interaction.

Module -3

Oxidation, Kinetics of oxidation, Factors controlling oxidation, Hot Corrosion, Testing methods, Mechanisms of hot corrosion, erosion, Hot corrosion properties of carbon steels and stainless steels.

Module -4

Super alloys: their processing, high temperature mechanical properties, Corrosion behaviour, Ceramics for applications in refractory technology, Properties and applications of high temperature polymers.

Module -5

Refractory metals and alloys, Intermetallics, Carbon-Carbon composites, Ceramic matrix composites for refractory applications, Industrial, defence and nuclear applications.

Text Books:

1. Creep of metals and alloys - Evans, R.W and Wilshire, B., Institute of metals, London, 1985.
2. Heat- resistant materials - J.R. Davis, ASM Specialty Handbook: ASM, 1997.

Course Outcomes:

At the end of the course the student will be able to:

- **CO-1:** Outline the different processes responsible for failure of materials at high temperature.
- **CO-2:** Able to relate the causes for creep failure and choice of creep resistant materials.
- **CO-3:** Able to interpret the structural changes taking place during fatigue and aging and carryout analysis of data.
- **CO-4:** Able to interpret the chemical causes for failure at high temperature.
- **CO-5:** Distinguish the role of ceramics, polymers, super alloys etc., at high temperature.
- **CO-6:** Analysis of data available for design and improve the existing materials.

Course Outcome No	Statement	Knowledge Level (KL)
CO1	Outline the different processes responsible for failure of materials at high temperature.	K1
CO2	Able to relate the causes for creep failure and choice of creep resistant materials.	K3
CO3	Able to interpret the structural changes taking place during fatigue and aging and carryout analysis of data.	K1
CO4	Able to interpret the chemical causes for failure at high temperature.	K4
CO5	Distinguish the role of ceramics, polymers, super alloys etc., at high temperature.	K3
CO6	Analysis of data available for design and improve the existing materials.	K3

KL – Bloom's Knowledge Level (K_1, K_2, K_3, K_4, K_5, K_6)

K_1- Remember, K_2 – Understand, K_3 – Apply, K_4 – Analyze, K_5- Evaluate, K_6 – Create

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3			3				2	1			
CO2	2				1		1	3	3			
CO3	3		2	3				1	1			
CO4												
CO5												
CO6												
CO Average	2.66		2	3	1		1	2	1.66			

3 - High; 2 - Medium; 1 – Low

Reference Books:

1. Introduction to the High Temperature Oxidation of Metals - Neil Birks, Gerald H. Meier, and Frederick S. Pettit, 2009.
2. The Super-alloys: Fundamentals and Applications, 1st edition - Roger C. Reed, Cambridge University Press, 2008.
3. High Temperature Coatings, 1st edition - Sudhansu Bose, Published by Butterworth-Heinemann, 2007.
4. Polyimides and Other High Temperature Polymers: Synthesis, Characterization and Applications - K. L. Mittal, Brill Academic Publications, 2009.

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