DEPARTMENT OF MATERIALS AND METALLUGICAL ENGINEERING
INDUS INSTITUTE OF TECHNOLOGY AND ENGINEERING
INDUS UNIVERSITY

Teaching Scheme 2021-2022

B. TECH IN METALLURGICAL ENGINEERING, SEMESTER–II TEACHING & EXAMINATION SCHEME												
SR. NO	CODE	SUBJECTS	TEACHING SCHEME			CREDITS	HOURS	EXAMINATION SCHEME				
								THEORY		PRACT		TOTAL
			L	T	P			CIE	ESE	CIE	ESE	
1	MA0311	Probability, Statistics and Numerical Methods	3	1	0	4	4	60	40	0	0	100
2	MME0301	Mineral Processing	3	0	2	4	5	60	40	60	40	200
3	MME0302	Physical Metallurgy	3	0	2	4	5	60	40	60	40	200
4	MME0303	Metallurgical Thermodynamics	3	1	0	4	4	60	40	0	0	100
5	SS0301	Human Values and Professional Ethics	2	0	0	2	2	60	40	0	0	100
6	BB0311	Management for Engineers	2	0	0	2	2	60	40	0	0	100
7	MME0304	Internship – I	0	0	0	2	0	0	0	60	40	100
TOTAL			**16**	**2**	**4**	**22**	**22**	**360**	**240**	**180**	**120**	**900**

DEPARTMENT OF MATERIALS AND METALLUGICAL ENGINEERING
INDUS INSTITUTE OF TECHNOLOGY AND ENGINEERING
INDUS UNIVERSITY

B. TECH IN METALLURGICAL ENGINEERING, SEMESTER–IV TEACHING & EXAMINATION SCHEME													
SR. NO	CODE	SUBJECTS	TEACHING SCHEME			CREDITS	HOURS	EXAMINATION SCHEME				TOTAL
			L	T	P			THEORY		PRACT		
								CIE	ESE	CIE	ESE	
1	MME0401	Introduction to Process Metallurgy	3	1	0	4	4	60	40	0	0	100
	MME0408	Bio and Smart Materials										
	MME0409	Cryogenic Treatment of Materials										
2	MME0402	Iron Making	3	0	2	4	5	60	40	60	40	200
3	MME0403	Transport Phenomena	3	1	2	5	6	60	40	60	40	200
4	MME0404	Heat Treatment Principles and Practices	3	0	2	4	5	60	40	60	40	200
5	EN0411	Soft skills and Interpersonal Communication	1	0	2	2	3	60	40	60	40	200
6	MME0405	Metal Casting and Solidification (OE – 4)	3	0	0	3	3	60	40	0	0	100
7	MME0406	Recycling of Materials (OE – 5)	3	0	0	3	3	60	40	0	0	100
8	MME0407	Personality Credit – I	0	0	0	2	0	0	0	0	0	100
TOTAL			**18**	**2**	**8**	**27**	**29**	**420**	**280**	**240**	**160**	**900**

DEPARTMENT OF MATERIALS AND METALLUGICAL ENGINEERING
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INDUS UNIVERSITY

B. TECH IN METALLURGICAL ENGINEERING, SEMESTER–V TEACHING & EXAMINATION SCHEME												
SR. NO	CODE	SUBJECTS	TEACHING SCHEME			CREDITS	HOURS	EXAMINATION SCHEME				
								THEORY		PRACT		TOTAL
			L	T	P			CIE	ESE	CIE	ESE	
1	MME0501	Steel Making	3	0	0	3	3	60	40	0	0	100
2	MME0502	Non Ferrous Extractive Metallurgy	3	0	0	3	3	60	40	0	0	100
3	MME0503	Plastic Deformation of Metals	3	1	0	4	4	60	40	0	0	100
4	MME0504	Foundry Technology	3	0	2	4	5	60	40	60	40	200
5	MME0505	Fuels, Furnaces and Refractories (EL – 1)	3	0	0	3	3	60	40	0	0	100
	MME0506	Environmental Pollution and Control in Metallurgical Industries (EL – 1)										
	MME0510	Additive Manufacturing (EL – 1)										
6	BB0521	Organizational Behaviour	2	0	0	2	2	60	40	0	0	100
7	BB0520	Entrepreneurship Development	2	0	0	2	2	60	40	0	0	100
8	MME0508	Energy Economy and Waste Management (OL – 6)	3	0	0	3	3	60	40	0	0	100
9	MME0509	Internship – II	0	0	0	2	0	0	0	60	40	100
TOTAL			**22**	**1**	**2**	**26**	**25**	**480**	**320**	**120**	**80**	**1000**

DEPARTMENT OF MATERIALS AND METALLUGICAL ENGINEERING
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INDUS UNIVERSITY

B. TECH IN METALLURGICAL ENGINEERING, SEMESTER–VI TEACHING & EXAMINATION SCHEME												
SR. NO	CODE	SUBJECTS	TEACHING SCHEME			CREDITS	HOURS	EXAMINATION SCHEME				
								THEORY		PRACT		TOTAL
			L	T	P			CIE	ESE	CIE	ESE	
1	MME0601	Metal Forming	3	1	0	4	4	60	40	0	0	100
2	MME0608	Powder Metallurgy	3	0	0	3	3	60	40	0	0	100
3	MME0603	Electrometallurgy and Corrosion	3	0	2	4	5	60	40	60	40	200
4	MME0604	Metal Joining Processes	3	0	2	4	5	60	40	60	40	200
5	MME0605	Composite Materials (EL – 2)	3	0	0	3	3	60	40	0	0	100
	MME0609	Modelling of Metallurgical Processes (EL-2)										
	MME0607	Nano Technology (EL – 2)										
6	MME0602	Phase Transformations (EL –3)	3	0	0	3	3	60	40	0	0	100
	MME0606	Industrial Ceramics and Polymers (EL – 3)										
	MME0610	Advanced Materials and Applications (EL – 3)										
8	MME0613	Introduction to Nano Materials (OE – 7)	3	0	0	3	3	60	40	0	0	100
9	MME0612	Personality Credit – II	0	0	0	2	0	0	0	0	0	100
TOTAL			**22**	**1**	**4**	**26**	**26**	**420**	**280**	**120**	**80**	**1000**

DEPARTMENT OF MATERIALS AND METALLUGICAL ENGINEERING
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B. TECH IN METALLURGICAL ENGINEERING, SEMESTER–VII TEACHING & EXAMINATION SCHEME												
SR. NO	CODE	SUBJECTS	TEACHING SCHEME			CREDITS	HOURS	EXAMINATION SCHEME				
								THEORY		PRACT		TOTAL
			L	T	P			CIE	ESE	CIE	ESE	
1	MME0701	Material Testing and Characterization	3	0	2	4	5	60	40	60	40	200
2	MME0702	Alloy Design (EL – 4)	3	0	0	3	3	60	40	0	0	100
	MME0703	Surface Engineering (EL – 4)										
	MME0704	Nuclear Metallurgy (EL – 4)										
3	MME0705	Advanced Ferrous Metallurgy (EL – 5)	3	0	0	3	3	60	40	0	0	100
	MME0706	Selection of Materials and Failure Analysis (EL – 5)										
	MME0707	Computational Materials Science (EL – 5)										
4	MME0708	Non-Destructive Testing (EL – 6)	3	0	0	3	3	60	40	0	0	100
	MME0709	Advanced Foundry Technology (EL – 6)										
	MME0710	Industrial Welding Codes and Standards (EL – 6)										
5	MME0715	Minor Project	0	0	6	3	6	0	0	60	40	100
6	MME0716	Failure Analysis (OE – 8)	3	0	0	3	3	60	40	0	0	100
7	MME0717	Introduction to Non-Destructive Evaluation (OE – 9)	3	0	0	3	3	60	40	0	0	100
8	MME0714	Internship – III	0	0	0	2	0	0	0	60	40	100
TOTAL			**18**	**0**	**8**	**24**	**26**	**360**	**240**	**180**	**120**	**900**

DEPARTMENT OF MATERIALS AND METALLUGICAL ENGINEERING
INDUS INSTITUTE OF TECHNOLOGY AND ENGINEERING
INDUS UNIVERSITY

B. TECH IN METALLURGICAL ENGINEERING, SEMESTER–VIII TEACHING & EXAMINATION SCHEME

SR. NO	CODE	SUBJECTS	TEACHING SCHEME			CREDITS	HOURS	EXAMINATION SCHEME				
								THEORY		PRACT		TOTAL
			L	T	P			CIE	ESE	CIE	ESE	
1	MME0801	Research Project	0	0	24	12	24	0	0	60	40	100
TOTAL			0	0	24	12	24	0	0	60	40	100

DEPARTMENT OF MATERIALS AND METALLUGICAL ENGINEERING
INDUS INSTITUTE OF TECHNOLOGY AND ENGINEERING
INDUS UNIVERSITY

Syllabus
1ST SEMESTER

DEPARTMENT OF MATERIALS AND METALLUGICAL ENGINEERING
INDUS INSTITUTE OF TECHNOLOGY AND ENGINEERING
INDUS UNIVERSITY

Subject: **Introduction to Engineering Materials**								
Program: **B. Tech in Metallurgical Engineering**				Subject Code: **MME0103**			Semester: **I**	
Teaching Scheme (Hours per week)				**Examination Evaluation Scheme (Marks)**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	0	0	3	16/40	0	24/60	0	100

Course Objectives

1. To evaluate different materials for engineering applications.
2. To categorize material according to their properties and requirement.
3. To classify materials and understand the importance of each material in order to find applications in other fields of engineering.

CONTENTS

UNIT-I

[10 hours]

Materials

Introduction, Engineering requirement of different materials, Classification of Engineering materials, Properties of engineering materials, Criteria for selection of materials for engineering application.

Crystal Physics

Structure of crystalline solids; Lattices, unit cells; atom size, co-ordination number, atomic packing factor., Indexing of directions and planes, notations, Interplanar spacing and angles, Crystal structure analysis - Bragg's law for X-ray diffraction.

UNIT-II

[10 hours]

Ferrous metals & Alloys

Pig iron, cast iron, carbon steel, alloy steels- Classification, properties, composition and applications.

Non-Ferrous Metals & Alloys

Important non-ferrous metals (Al, Cu, Pb, Zn, Sn, Mg, Ti, Ni,), Non-ferrous alloys (Cu alloys, Al alloys, Mg-alloys, Ni-alloys) – Composition, properties, classification and applications.

UNIT-III

[10 hours]

Ceramics

Introduction, Simple crystal structure, Classification- Traditional (clay-products, refractories, abrasives, cement) and Engineering Ceramics - Glass Ceramics, Properties of ceramics,

Application of Ceramics, Glasses, Glass structure, Properties and application of Glass, Types of glass.

Polymers

Introduction, Classification and forms of Polymers, Thermosetting & thermoplastic polymer, types of polymerizations, Molecular weight, Plastics, Natural rubber and synthetic rubber, Applications of polymeric materials.

UNIT-IV

[10 hours]

Composites

Introduction, Classification & Applications, Dispersion-strengthened, Composites, Particulate Composites, Fiber-reinforced Composites: Influence of Fiber Length, Influence of Fiber Orientation and Concentration, The Fiber Phase, The Matrix Phase, Polymer-Matrix.
Composites, Metal-Matrix Composites, Ceramic - Matrix Composites, Carbon–Carbon Composites, Processing of Fiber-Reinforced Composites.

Advanced Materials

Smart materials (Shape memory material, Piezo electric material) Photoconductors, Bio-materials, Nano materials, Dielectric materials, magnetic materials, metamaterials, Cryogenics, Optical Fiber.

Course Outcomes

1. To apply the fundamentals of mass, matter and materials from daily life.
2. To acquaint the student with applications and properties of materials used from engineering aspects.
3. To apply student's knowledge about advanced materials to be used in futuristic applications.

Text Books

1. O. P. Khanna, "Material Science and Metallurgy", Dalpat Rai Publications, 2nd Edition, 2014, ISBN: 9789383182459.
2. R. K Rajput, "Engineering Materials", S. Chand Publications, 4th Edition, 2000, ISBN: 9788121919609.
3. W.D. Callister, "Material Science & Engineering – An Introduction", John Wiley Publishers, 7th Edition, 2007, ISBN: 9780471736967.

Reference Books

1. J. Shackelford, "Introduction to Materials Science for Engineers", Pearson-Prentice Hall Publications, 8th Edition, 2006, ISBN: 8131700909.
2. L.H. Vanvlack, "Elements of Materials Science and Engineering", Pearson Education India, 6th Edition, 2002, ISBN: 8131706001.
3. D. Swarup, "Elements of Metallurgy", Rastogi Publications, 2005, ISBN: 8171338135.
4. V. Raghavan, "Materials Science and Engineering – A First Course", Prentice Hall India Learning Private Limited, 6th Edition, 2015, ISBN: 8120350928.

Web Resources

1. MOOC Course on “Materials Science and Engineering”
(https://www.edx.org/course/materials-science-engineering-misisx-mse1x)

DEPARTMENT OF MATERIALS AND METALLUGICAL ENGINEERING
INDUS INSTITUTE OF TECHNOLOGY AND ENGINEERING
INDUS UNIVERSITY

Subject: **Materials Science (OE – 1)**								
Program: **B. Tech in Metallurgical Engineering**				Subject Code: **MME0102**			Semester: **I**	
Teaching Scheme (Hours per week)				**Examination Evaluation Scheme (Marks)**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	0	0	3	16/40	0	24/60	0	100

Course Objectives

1. To evaluate different materials for engineering applications.
2. To categorize material according to their properties and requirement.
3. To classify materials and understand the importance of each material in order to find applications in other fields of engineering.

CONTENTS

UNIT-I

[10 hours]

Materials

Introduction, Engineering requirement of different materials, Classification of Engineering materials, Properties of engineering materials, Criteria for selection of materials for engineering application.

UNIT-II

[10 hours]

Ferrous metals & Alloys

Pig iron, cast iron, carbon steel, alloy steels- Classification, properties, composition and applications.

Non-Ferrous Metals & Alloys

Important non-ferrous metals (Al, Cu, Pb, Zn, Sn, Mg, Ti, Ni,), Non-ferrous alloys (Cu alloys, Al alloys, Mg-alloys, Ni-alloys) – Composition, properties, classification and applications.

UNIT-III

[10 hours]

Ceramics

Introduction, Simple crystal structure, Classification- Traditional (clay-products, refractories, abrasives, cement) and Engineering Ceramics- Glass Ceramics, Properties of ceramics, Application of Ceramics, Glasses, Glass structure, Properties and application of Glass, Types of glass.

Polymers

Introduction, Classification and forms of Polymers, Thermosetting & thermoplastic polymer, types of polymerizations, Molecular weight, Plastics, Natural rubber and synthetic rubber, Applications of polymeric materials.

UNIT-IV

[10 hours]

Composites

Introduction, Classification & Applications, Dispersion-strengthened, Composites, Particulate Composites, Fiber-reinforced Composites: Influence of Fiber Length, Influence of Fiber Orientation and Concentration, The Fiber Phase, The Matrix Phase, Polymer-Matrix.
Composites, Metal-Matrix Composites, Ceramic - Matrix Composites, Carbon–Carbon Composites, Processing of Fiber-Reinforced Composites.

Advanced Materials

Smart materials (Shape memory material, Piezo electric material) Photoconductors, Bio-materials, Nano materials, Dielectric materials, magnetic materials, metamaterials, Cryogenics, Optical Fiber.

Course Outcomes

1. To apply the fundamentals of mass, matter and materials from daily life.
2. To acquaint the student with applications and properties of materials used from engineering aspects.
3. To apply student's knowledge about advanced materials to be used in futuristic applications.

Text Books

1. O. P. Khanna, "Material Science and Metallurgy", Dalpat Rai Publications, 2nd Edition, 2014, ISBN: 9789383182459.
2. R. K Rajput, "Engineering Materials", S. Chand Publications, 4th Edition, 2000, ISBN: 9788121919609.
3. W.D. Callister, "Material Science & Engineering – An Introduction", John Wiley Publishers, 7th Edition, 2007, ISBN: 9780471736967.

Reference Books

1. J. Shackelford, "Introduction to Materials Science for Engineers", Pearson-Prentice Hall Publications, 8th Edition, 2006, ISBN: 8131700909.
2. L.H. Vanvlack, "Elements of Materials Science and Engineering", Pearson Education India, 6th Edition, 2002, ISBN: 8131706001.
3. D. Swarup, "Elements of Metallurgy", Rastogi Publications, 2005, ISBN: 8171338135.
4. V. Raghavan, "Materials Science and Engineering – A First Course", Prentice Hall India Learning Private Limited, 6th Edition, 2015, ISBN: 8120350928.

Web Resources

1. MOOC Course on "Materials Science and Engineering"
(https://www.edx.org/course/materials-science-engineering-misisx-mse1x)

2ND SEMESTER

DEPARTMENT OF MATERIALS AND METALLUGICAL ENGINEERING
INDUS INSTITUTE OF TECHNOLOGY AND ENGINEERING
INDUS UNIVERSITY

Subject: **Structural Metallurgy and Physics of Materials**								
Program: **B. Tech in Metallurgical Engineering**				Subject Code: **MME0201**			Semester: **II**	
Teaching Scheme (Hours per week)				**Examination Evaluation Scheme (Marks)**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	0	0	3	16/40	0	24/60	0	100

Course Objectives

1. To give them knowledge about diffusion in solids.
2. To teach them basics on nucleation and growth and its applications.
3. To teach them about crystal defects in metallic materials their origin, causes and remedial measure.
4. To provide basic knowledge about properties of materials such as electrical and thermal Conductivity, magnetism, dielectric properties.

CONTENTS

UNIT-I

[10 hours]

Atomic Structure, types of bonds; ionic bonds, covalent bonds, Van der Waals bonds, metallic bonds, metallic properties; crystalline vs. non-crystalline solids. Inter-atomic Bonding, Inter-atomic distances.

Macro and micro structure in metallic materials, levels of structure, structure property relationships in materials, Equilibrium & kinetics: stability & met stability, Basic thermodynamic functions, The statistical nature of entropy.

UNIT-II

[10 hours]

The Structure of Crystalline Solids: Crystalline & non crystalline states, covalent solids, Metals & alloys. Ionic solid, unit cell, space lattice, Crystal geometry, crystal systems & Miller- Bravais lattices, Polymorphism or allotropy, direction & planes, slip planes, atom sizes, co-ordination number, atomic packing factor.

UNIT-III

[10 hours]

Isotropy & anisotropy, Homogenous & heterogeneous, Defects, Types of defects, Stress-strain diagram, Types of deformation elastic & anelastic deformation, viscoelastic behavior, work hardening & strain hardening, dislocation & strain aging.

UNIT-IV

[10 hours]

Glass transition, Conductors and Resistors: The resistivity range, Free electron theory, conduction by free electrons, conductor, Semi- conductor, insulators and resistor materials.

Ferromagnetism, diamagnetism, paramagnetism, superconductivity, dielectric behavior, thermal conductivity principles.

Course Outcomes

1. To apply the knowledge about the basic structure of metals and alloys, which are the building block for developing macro and micro structure of metallic materials.
2. To apply the knowledge about metallic and non-metallic type of bonding and their differentiation.
3. To apply the concept of polymorphism and others.
4. To solve different numerical pertaining to crystal structure determination & phase diagram determination.

Text Books

1. C. S. Barret & T. B. Massalski, "Structure of Metals – Crystallographic Methods, Principles & Data", McGraw-Hill Book Company, 3rd Edition, 1966, ISBN: 9780070038158.
2. A. H. Cottrell, "Theoretical Structural Metallurgy", The English Language Book Society & Edward Arnold (Publishers) Ltd., 2nd Edition, 1964, OCLC: 959782723.
3. B. D. Cullity, "Elements of X-ray Diffraction", Pearson New International, 3rd Edition, 2014, ISBN: 9781292040547.
4. R. Abbaschian, L. Abbaschian and R. E. Reed-Hill, "Physical Metallurgy Principles", Stamford CT: Cengage Learning, 4th Edition, 2010, ISBN: 9780495438519.

Reference Books

1. V. Raghavan, "Materials Science & Engineering", Prentice-Hall of India Pvt. Ltd, 6th Edition, 2015, ISBN: 9788120350922.

Web Resources

1. MIT Open Courseware on "Materials Science and Engineering"
(http://ocw.mit.edu/OcwWeb/Materials-Science-and-Engineering/)
2. EdX Course on "Materials Science and Engineering"
(https://www.edx.org/course/materials-science-engineering-misisx-mse1x)
3. NPTEL MOOC Course on "Physics of Materials"
(https://onlinecourses.nptel.ac.in/noc16_mm08/preview)
4. NPTEL MOOC Course on "Physics of Materials"
(https://onlinecourses.nptel.ac.in/noc15_mm03/preview)
5. NPTEL MOOC Course on "Nature and Properties of Materials"
(https://onlinecourses.nptel.ac.in/noc17_me27/preview)
(https://onlinecourses.nptel.ac.in/noc16_me16/preview)

DEPARTMENT OF MATERIALS AND METALLUGICAL ENGINEERING
INDUS INSTITUTE OF TECHNOLOGY AND ENGINEERING
INDUS UNIVERSITY

Subject: **Metallurgy for Non-Metallurgists (OE – 2)**								
Program: **B. Tech in Metallurgical Engineering**				Subject Code: **MME0202**			Semester: **II**	
Teaching Scheme (Hours per week)				**Examination Evaluation Scheme (Marks)**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	0	0	3	16/40	0	24/60	0	100

Course Objectives

1. Every human being particularly who are not familiar with metallurgy would be curious to know about the behavior of these metals and alloys, their applications in industries and in every walk of human life.
2. This course aims at providing knowledge and understanding to the students not only about the extraction of metals but also their manufacturing processes into different shapes and sizes, their properties, testing and applications.

CONTENTS

UNIT-I

[10 hours]

Introduction to Metallurgy
Metal Extraction from Ores

UNIT-II

[10 hours]

Metallography and its applications
Mechanical properties of metals and alloys, Strengthening Mechanism

UNIT-III

[10 hours]

Heat treatment processes
Manufacturing processes such as Rolling, Forging, Casting and Welding

UNIT-IV

[10 hours]

Introduction to Corrosion science and engineering
Treatment of steels such as Plating, Galvanizing, Aluminizing
Destructive and Non-Destructive Testing

Course Outcomes

1. The students will be made familiar with different types of ferrous and non-ferrous metals and their brief introduction to extraction processes from respective ores and minerals.
2. Refining and alloying of metals and alloys and their properties, microstructural characteristics.
3. Manufacturing processes such as Rolling, Forging, and Casting and welding.
4. Testing of metallic components destructively and non-destructively.
5. Heat treatment processes for their change in the microstructure and mechanical properties.
6. Corrosion behavior of metals and materials.

Text Books

1. Elements of Metallurgy – D. Swarup.
2. O. P. Khanna, "Material Science and Metallurgy", Dalpat Rai Publications, 2nd Edition, 2014, ISBN: 9789383182459.

Reference Books

1. Short Term Course Material on Metallurgy for Non-Metallurgists by I. I. M., Baroda Chapter.

DEPARTMENT OF MATERIALS AND METALLUGICAL ENGINEERING
INDUS INSTITUTE OF TECHNOLOGY AND ENGINEERING
INDUS UNIVERSITY

Subject: **Testing of Materials (OE – 3)**								
Program: **B. Tech in Metallurgical Engineering**				Subject Code: **MME0204**			Semester: **II**	
Teaching Scheme (Hours per week)				**Examination Evaluation Scheme (Marks)**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	0	0	3	16/40	0	24/60	0	100

Course Objectives

1. To introduce the various testing to know the fundamental properties of engineering materials.
2. To understand the working principle of various testing instruments.
3. Able to identify the appropriate testing method to know the properties.

CONTENTS

UNIT-I

[10 hours]

Overview of materials and its properties. Classification of material testing, Purpose of testing, Quantitative and qualitative analysis. Development of testing, testing organizations and its committee, Testing standards, Advantages of testing.

UNIT-II

[10 hours]

Introduction to mechanical testing, Hardness test (Vickers, Brinell, Rockwell), Tensile test, Impact test (Izod, Charpy) - Principles, Techniques, Methods, Standards, Advantages and Limitations, Applications. Bend test, Shear test, Creep and Fatigue test - Principles, Techniques, Methods, Standards, Advantages and Limitations, Applications.

UNIT-III

[10 hours]

Visual inspection, Liquid penetrant test, Magnetic particle test, Thermography test – Principles, Techniques, Advantages and Limitations, Applications. Radiographic test, Eddy current test, Ultrasonic test, Acoustic emission- Principles, Techniques, Methods, Standards, Advantages and Limitations, Applications.

UNIT-IV

[10 hours]

Macroscopic and Microscopic observations, Optical and Electron microscopy (SEM and TEM) - Principles, Types, Advantages and Limitations, Applications. Thermal Analysis (TGA and DSC) – Principles, Technique, Advantage and limitations, Applications.

Course Outcomes

1. To apply knowledge of mathematics, science, and engineering in testing of materials.
2. To apply the knowledge of the various testing method to evaluate the properties.
3. To appreciate the selection of materials based on the properties of materials.

TEXT BOOKS:

1. P. Field Foster, "The Mechanical Testing of Metals and Alloys" 7th Edition, Cousens Press, 2007.

2. Baldev Raj, T.Jayakumar, M.Thavasimuthu "Practical Non-Destructive Testing", Narosa Publishing House, 2009.

3. Suryanarayana A K, "Testing of Metallic Materials", Prentice Hall of India Pvt. Ltd. New Delhi.

3. Phillips V A, "Modern Metallographic Techniques and their Applications", Wiley Eastern,1971.

REFERENCES:

1. Metals Handbook: Mechanical testing, (Volume 8) ASM Handbook Committee, 9th Edition, American Society for Metals, 1978.

2. ASM Metals Handbook, "Non-Destructive Evaluation and Quality Control", American Society of Metals, Metals Park, Ohio, USA.

3. Brandon D.G., "Modern Techniques in Metallography", Von Nostrand Inc. NJ, USA, 1986.

4. Whan R E (Ed), ASM Handbook, Volume 10, "Materials Characterization ", Nineth Edition, ASM international, USA, 1986.

Web Resources

1. NPTEL Course on "Rapid Manufacturing"
(https://nptel.ac.in/courses/112/104/112104265/)
2. NPTEL Course on "The future of Manufacturing Business: Role of Digital Technology"
(https://nptel.ac.in/courses/110/106/110106146/)

3RD SEMESTER

DEPARTMENT OF MATERIALS AND METALLUGICAL ENGINEERING
INDUS INSTITUTE OF TECHNOLOGY AND ENGINEERING
INDUS UNIVERSITY

Subject: **Mineral Processing**								
Program: **B. Tech in Metallurgical Engineering**				Subject Code: **MME0301**			Semester: **III**	
Teaching Scheme (Hours per week)				**Examination Evaluation Scheme (Marks)**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	0	2	4	16/40	16/40	24/60	24/60	200

Course Objectives

1. To make the students aware about basics of mining technology.
2. To impart the knowledge about the basic steps followed in mineral dressing and its importance before extraction of pure metal from their respective ores.
3. To develop the knowledge regarding the auxiliary operation and the advancement in mining technology.

CONTENTS

UNIT-I

[10 hours]

Introduction and scope of mineral processing in extractive metallurgy, mineral resources in India, physical characteristics exploited in mineral processing, terminology in mineral processing. Physical and chemical characteristics of industrial minerals i.e. hematite, magnetite, galena, chalcopyrite, azurite, monazite, cassiterite, chromite, bauxite, and ilmenite, economics of ore processing.

UNIT-II

[10 hours]

Liberation and its significance, Comminution and sizing, Laws of comminution, Crushing and Grinding- types, equipment, washing, sorting and hand-picking; Laboratory and industrial screening- equipment, screen efficiency.

UNIT-III

[10 hours]

Classifier- mechanical and hydraulic, sizing and sorting, classifiers, Mill calculation and Selectivity index. Gravity concentration methods, Tabling, Jigging, Heavy media separation, Separation in vertical and streaming currents, Sedimentation, Dewatering, techniques, Thickener, Filtration and Drying.

UNIT-IV

[10 hours]

Froth flotation: principles, reagents, collectors, modifiers and frothers, process variables in

floatation, Tailings disposal, Process integration and, Study of flow sheet for important minerals. Magnetic and Electrostatic separation: principles, wet and dry separators, High tension separation, Motion of solid in fluid, Strokes and Newton's law, Free and hindered settling, Thickening, Batch and continuous settling, chambers. Application of computer in mineral processing.

Mineral Processing Lab (List of Experiments)

Experiment No.	Title
1	To study the crushers (primary and secondary) like jaw crusher and roll crusher and to measure their reduction ratios and capacities
2	To determine the reduction ratio of Coal.
3	To determine the reduction ratio of Coke.
4	To determine the reduction ratio of Iron ore.
5	To determine the reduction ratio of Ceramic material.
6	To study the sieve analysis of weighed powder sample
7	To study the ball mill and measure the grind ability of Ball mill
8	To determine the grindability of Coal.
9	To determine the grindability of coke.
10	To determine the grindability of Iron ore.
11	To determine the grindability of ceramic material.
12	To study the principle , operation and efficiency of laboratory classifier
13	To determine the efficiency of magnetic separation by varying strength of magnetic field
14	To study the coal and gravel separation using jig
15	To study the froth flotation of given sample of coal

Course Outcomes

1. To apply the knowledge of mineral processing to advance in the field of extraction.
2. To apply the basic principles behind ore dressing to different ores and minerals.

Text Books

1. S. K. Jain, “Mineral Processing”, CBS Publishers & Distributors, 2nd Edition, 2012, ISBN: 9788123907536.

Reference Books

1. A. M. Gaudin, "Principles of Mineral Dressing", Tata McGraw Hill Publications, 1st Edition, 1939, ISBN: 9780070230309.
2. B. A. Wills and J. Finch, "Mineral Processing Technology", Butterworth-Heinemann, 8thEdition, 2015, ISBN: 9780080970530.
3. E. G. Kelly and D. J. Spottiswood, "Introduction to Mineral Processing", John Wiley & Sons Inc, 1982, ISBN: 9780471033790.
4. J. D. Gilchrist, "Extraction Metallurgy", Pergamon Press, 1st Edition, 1967, ISBN: 9780080120300.
5. E. J. Pryor, "Mineral Processing", Springer Netherlands, 3rdEdition, 1965, ISBN: 9789401029438.
6. J. Newton, "Extractive Metallurgy", John Wiley & Sons Inc, 1stEdition, 1959, ISBN: 9780471635918.
7. H. S. Ray, R. Sridhar and K. P. Abraham, "Extraction of Non-ferrous Metals", Affiliated East-west Press Pvt Ltd, 1stEdition, 2008, ISBN: 9788185095639.

Web Resources

1. NPTEL Course on "Non-ferrous Extractive Metallurgy"
(http://nptel.ac.in/courses/113105021/)

DEPARTMENT OF MATERIALS AND METALLUGICAL ENGINEERING
INDUS INSTITUTE OF TECHNOLOGY AND ENGINEERING
INDUS UNIVERSITY

Subject: **Physical Metallurgy**								
Program: **B. Tech in Metallurgical Engineering**				Subject Code: **MME0302**			Semester: **III**	
Teaching Scheme (Hours per week)				**Examination Evaluation Scheme (Marks)**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	0	2	4	16/40	16/40	24/60	24/60	200

Course Objectives

1. To introduce the engineering science principles and applications associated with physical metallurgy.
2. To study the physical aspect behind metallurgical phenomena.
3. To study the structure of metals and its influence on material properties and performance

CONTENTS

UNIT-I

Introduction, solid Solution, Types of solid solution, Hume-Rothery Rules for Primary Substitutional Solid Solubility, Types of Interstitial Voids, Chemical compounds versus solidsolution, Intermediate Phases, Polycrystalline Materials, Grain Size, Measurement of Grain Size, Multiple –Phase Alloys. Intermetallic compounds.

UNIT-II

Solidification of Metals & Alloys: Driving force for solidification, Nucleation and growth phenomena, Homogenous & Heterogeneous Nucleation, Growth of Solid, Smoothor Stable interface growth, Temperature Inversion in pure Metals, Segregation, Porosity.

Concepts of alloy system and explanation of terms like system, component, phase, micro constituent and degree of freedom, structural constituent of an alloy, phase rule and phase equilibria, equilibrium diagrams and their classification based on solubility of components in liquid and solid states, cooling curves, morphology and distribution of phases, effect of non-equilibrium cooling on morphology.

UNIT-III

Constitutional super cooling Unary Diagram, Binary Phase Diagram, Use of Phase Diagram, Determination of Phase Diagrams, Limitation of Equilibrium Diagram, Ternary Diagram, Interpretation of Phase Diagram, Interpretation of Phase Diagram by using Lever Rule.

Introduction, Allotropy of Iron, Cooling & Heating curves of Pure Iron, Effect of pressure on allotropy of Iron, Iron- carbon equilibrium diagram, phase Fe- Fe3C diagram. Effect of Alloying element on Fe- Fe_3C diagram, effect of carbon on Fe- Fe_3C.Critical temperature in Fe- Fe_3C diagram. Interpretation of Phase Diagram.

UNIT-IV

Steels Classification and application of carbon steels, Plain carbon steels, Advantages and limitations of Plain carbon steels, Effect of impurity elements on the properties of steels, Purpose of alloying of steel, Functions of alloying elements in steel, Effects of alloying elements on the properties of steels, Steel Specifications-according to UNS. Introduction to cast irons, Various Types, Properties & Applications.

Metallography Microscopic examination, polishing techniques for different metals and alloys, Etching and Mounting techniques, Difference between Macro & Micro Etching, electrolytic polishing Metallurgical microscope, Macroscopic & Microscopic examination methods, Nonmetallic inclusions.

Physical Metallurgy (List of Experiments)

Experiment No.	Title
1	Study of optical microscope.
2	Specimen preparation for metallography.
3	Mounting of specimen.
4	Plotting of Thermal Equilibrium Phase Diagram of Binary alloys and pure metal by Cooling Curve Method.
5	Microstructure observation of Pure metals
6	Application of Lever Rule for Phase, Phase Composition & Phase Fraction (Binary Alloys)
7	Microstructural observation of Cast Irons.
8	Study of phase diagrams for structure-properties correlation.
9	Eutectic, Hypo- And Hyper-Eutectic Alloys: Al-Si (Unmodified), Al-Si (Modified), Pb-6wt%Sb, Pb- 11.1 Wt%Sb And Pb- 20 Wt%Sb

10	Peritectic And Monotectic Alloys: 60:40 (+) Brass, 70:30 ( ) Brass, Cu-10wt%Sn, Cu- 36wt% Pb, Cu- 50 Wt% Pb*
11	Grain size measurement

Text books

1. Physical Metallurgy Principles - Robert E Reed-Hill and Reza Abbaschian(2008)
2. Y. Lakhtin, "Engineering Physical Metallurgy", CBS Publishers & Distributors, 1st Edition, 2005, ISBN: 9788123906027.

Reference books

1. Phase Transformation in Metals & Alloys - D A Porter & K Easterling(1992)
2. Physical metallurgy by Avner-(1997)
3. Physical Metallurgy - Peter Haasen(1996)
4. Structure and Properties of Alloys - R M Brick, R B Gordon, A. Phillips(2002)
5. Physical Foundations of Materials Science - G. Gottstein (2004)
6. Physical Metallurgy and Advanced Materials Engineering - R.E. Smallman and A.H.W. Ngan (2007)

Web Resources

http://nptel.ac.in/courses/113105024/

DEPARTMENT OF MATERIALS AND METALLUGICAL ENGINEERING
INDUS INSTITUTE OF TECHNOLOGY AND ENGINEERING
INDUS UNIVERSITY

Subject: **Metallurgical Thermodynamics**								
Program: **B. Tech in Metallurgical Engineering**				Subject Code: **MME0303**				Semester: **III**
Teaching Scheme (Hours per week)				**Examination Evaluation Scheme (Marks)**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	1	0	4	16/40	0	24/60	0	100

Course Objectives

1. To get the knowledge about the basic concept of system, properties of system and thermodynamics.
2. To analyze and understand all the laws of thermodynamics.
3. To understand thermodynamics of solutions ideal & non ideal solution.

CONTENTS

UNIT-I

[10 hours]

Importance of thermodynamics, Definition of thermodynamic terms, Concept of system, states and equilibrium, Types of system, Extensive and intensive properties, Homogeneous and heterogeneous systems, Quasistatic process, Zeroth law of thermodynamics. First law of thermodynamics, Internal energy, Heat capacity, Specific heat and latent heat, Enthalpy, Isothermal and adiabatic processes.

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UNIT-II

[10 hours]

State properties, Heat of reaction, Heat of formation, Standard heats, Heat of transition, Hess's law, Kirchoff's law equation. Second law of thermodynamics, Entropy of irreversible processes, Auxiliary functions, combined statements of 1^{st} and 2^{nd} laws, Maxwell's relations,

Third law of thermodynamics, Temperature dependence of entropy, Statistical interpretation of entropy, Consequences of third law, Nernst heat theorem.

UNIT-III

[10 hours]

Concept of fugacity, activity and mole fraction, Activities in concentrated solution, Activity, Gas phase Reactions (H_2O- H_2 and CO_2 –CO mixtures), Activity in industrial liquid metallic solution, Equilibrium constant, Gibb's-Helmholtz equation. Van't-Hoff equation, Clausius – Clapeyron

equation, Reactions involving solid and gases, Thermodynamics of solutions, Ideal solution, Raoult's law, Henry's law, Non-ideal solution Gibb's-Duhem equation, Partial molar properties of mixing.

UNIT-IV

[10 hours]

Excess functions, Concept of 1 wt% standard state and Interaction coefficient, Regular solutions, Sievert's law-residual gases in steel, Phase relations and phase rule-its applications, Free energy-composition and temperature-composition diagrams for binary alloy systems and their correlation, determination of liquidus, solidus and solvus lines, Effect of pressure on phase transformation and phase equilibrium, Ellingham diagram in detail for metal oxides.

Course Outcomes

1. To demonstrate the application of various factors & mathematical equations governing the thermodynamics in the system.
2. To solve different numerical pertaining to all three laws of thermodynamics for different systems.
3. To demonstrate the phenomena of Ellingham diagram & its importance pertaining to metal oxides.
4. To describe basis of phase rule & its application and various equilibrium using thermodynamics and correlation for binary alloy systems.

Text Books

1. A. Ghosh, "Introduction to Materials and Metallurgical Thermodynamics", Prentice Hall India Learning Private Limited, 1st Edition, 2002, ISBN: 9788120320918.
2. S. K. Dutta and A. B. Lele, "Metallurgical Thermodynamics Kinetics & Numericals", S. Chand Publications, 2nd Edition, 2014, ISBN: 9788121939645.
3. D. R. Gaskell, "Introduction to the Thermodynamics of Materials", T&F, 5th Edition.

Reference Books

1. R. H. Tupkary, "Essentials of Metallurgical Thermodynamics", Khanna Publishers, 1st Edition, 2006, ISBN: 9789382609032.
2. G. S. Upadhyaya, R. K. Dube and D. W. Hopkins, "Problems in Metallurgical Thermodynamics and Kinetics", Pergamon Press, 1st Edition, 1977, ISBN: 9780080208640.
3. L. S. Darken and R. W. Gurry, "Physical Chemistry of Metals", CBS, 1st Edition, 2002, ISBN: 9788123914794.

Web Resources

1. NPTEL MOOC Course on "Laws of Thermodynamics"
(https://onlinecourses.nptel.ac.in/noc17_mm16/preview)
2. SWAYAM MOOC Course on "Engineering Thermodynamics"
(https://swayam.gov.in/course/3808-engineering-thermodynamics)
3. EdX Online Course on "Thermodynamics"
(https://www.edx.org/course/thermodynamics-iitbombayx-me209-1x-1)

4. NPTEL Online Course on "Advanced Metallurgical Thermodynamics" (http://nptel.ac.in/courses/113106031/)

4^{th} SEMESTER

Subject: **Introduction to Process Metallurgy (EL)**								
Program: **B. Tech in Metallurgical Engineering**				Subject Code: **MME0401**			Semester: **IV**	
Teaching Scheme (Hours per week)				**Examination Evaluation Scheme (Marks)**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	1	0	4	16/40	0	24/60	0	100

Course Objectives

1. To gain knowledge about the basic mechanism affecting the different extraction techniques such as Pyro-metallurgical, Hydrometallurgical & Electro metallurgical extraction processes.
2. To gain knowledge about the concept of reaction kinetics & its role in understanding the extraction processes.

CONTENTS

UNIT-I

[10 hours]

Pyro-metallurgical Processes

Basics of Pyro-metallurgical Processes, Drying, Calcination, Agglomeration, Sintering, Roasting, Smelting. Converting, Refining processes with examples for metals like Aluminum, Copper, Zinc, and Lead.

UNIT-II

[10 hours]

Hydrometallurgical Processes

Basics of Hydrometallurgical processes, Fundamentals of Unit processes and Unit operations, Principles and types of Leaching, Kinetics of leaching, and Refining of leached solution, Solvent extraction and ion-exchange processes, Cementation, Gaseous reduction of metals.

UNIT-III

[10 hours]

Electrometallurgical Processes

Basics of Electrometallurgical processes: Electrowinning and Electrorefining, Aqueous/Fused salt electrolysis. Flow-sheets of Extraction of Important Metals, Simplified Flowsheets for the production of Iron, Steel, Aluminum, Copper, Zinc and Lead.

UNIT-IV

[10 hours]

Reaction Kinetics

Kinetics of metallurgical processes and material, velocity/rate of reaction, factors affecting rate of reaction, Order of Reaction and molecularity, zero, first, second order and order of reaction,half-life period, determination of order of reaction, integration method, half period method, rate constants, Arrhenius equation, collision theory, Activation Energy, activation energy profile of an exothermic reaction, activation energy barrier, theory of absolute reaction rate.

Course Outcomes

1. To understand about the requirement of various devices required for carrying out different extraction processes.
2. To analyze and apply various factors affecting these extraction processes.

Text Books

1. H. S. Ray and A. Ghosh, "Principles of Extractive Metallurgy", New Age Publishers, 2nd Edition, 1991, ISBN: 9788122403220.
2. H.S. Ray, R. Sridhar and K.P. Abraham, "Extraction of Nonferrous Metals", Affiliated East West Press Pvt Ltd, 1st Edition, 2008, ISBN: 9788185095639.
3. S. K. Dutta and A. B. Lele, "Metallurgical Thermodynamics Kinetics & Numericals", S. Chand Publications, 2nd Edition, 2014, ISBN: 9788121939645.

Reference Books

1. W. H. Dennis, "Extractive Metallurgy", Pitman Publishing, 1st Edition, 1965, ISBN: 9780273404729.
2. F. Habashi, "Principles of Extractive Metallurgy", Gordon & Breach, 1st Edition, 1970, ISBN: 9780677017808.
3. T. Rosenqvist, "Principles of Extractive Metallurgy", McGraw Hill, 1st Edition, 1974, ISBN: 9780070538474.
4. J. L. Bray, "Nonferrous Production Metallurgy", John Wiley and Sons, 2nd Edition, 1947, ASIN: B0007E2TW6.
5. R. D. Pehlke, "Unit Processed in Extractive Metallurgy", Elsevier, 1st Edition, 1973, ISBN: 9780444001306.
6. H. S. Ray, "Introduction to Melts: Molten Salts, Slags and Glasses", Allied Publishers Pvt Ltd 1st Edition, 2006, ISBN: 9788177648751.
7. H.S. Ray, B.P Singh, S. Bhattacharjee and V. N. Misra, "Energy in Minerals and Metallurgical Industries", Allied Publishers Pvt Ltd, 1st Edition, 2005, ISBN: 8177648748.

Web Resources

1. NPTEL Course on "Non-Ferrous Extractive Metallurgy"
(http://nptel.ac.in/courses/113105021/)

DEPARTMENT OF MATERIALS AND METALLUGICAL ENGINEERING
INDUS INSTITUTE OF TECHNOLOGY AND ENGINEERING
INDUS UNIVERSITY

Subject: **Bio and Smart Materials (EL)**								
Program: **B. Tech in Metallurgical Engineering**				Subject Code: **MME0408**			Semester: **IV**	
Teaching Scheme (Hours per week)				**Examination Evaluation Scheme (Marks)**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	1	0	4	16/40	0	24/60	0	100

Course Objectives

1. To study applications of materials in biomedical engineering
2. To study applications of materials in special materials for actuators, sensors, etc.

UNIT I INTRODUCTION [10 hours]

Intelligent / Smart materials – Functional materials – Polyfunctional materials – Structural materials, Electrical materials, bio-compatible materials. – Intelligent biological materials – Biomimetics – Wolff's Law – Biocompatibility – Material response: swelling and leaching, corrosion and dissolution, deformation and failure, friction and wear – host response: the inflammatory process – coagulation and hemolysis – in vitro and in vivo evaluation of biomaterials.

UNIT II ELECTRO-RHEOLOGICAL AND PIEZOELECTRIC MATERIALS [10 hours]

The principal ingredients of smart materials –microsensors- hybrid smart materials - an algorithm for synthesizing smart materials – active, passive reactive actuator based smart structures- suspensions and electro-rheological fluids - Bingham body model – principal characteristics of electro-rheological fluids – charge migration mechanism for the dispersed phase – electro- rheological fluid domain – fluid actuators- design parameter – application of Electo-rheological fluids – Basics, Principles and instrumentation and application of Magnetorheological fluids

– Piezoelectric materials: polymers and ceramics, mechanism, properties and application. Introduction to electro-restrictive and magneto-restrictive materials

UNIT III SHAPE MEMORY MATERIALS [10 hours]

Nickel – Titanium alloy (Nitinol) – Materials characteristics of Nitinol – martensitic transformations – austenitic transformations – thermoelastic martensitic transformations–

classification of SMA alloys- mechanism of magnetic SMA – applications of SMA – continuum applications of SMA fasteners – SMA fibers – reaction vessels, nuclear reactors, chemical plant, etc. – micro robot actuated by SMA – SMA memorization process (Satellite Antenna Applications) SMA blood clot filter – Impediments to applications of SMA – Shape memory polymers– mechanism of shape memory-Primary moulding – secondary moulding – types and applications.

UNIT IV ORTHOPAEDIC AND DENTAL MATERIALS [10 hours]

Bone and teeth composition, formation and properties – bioresorbable, bioinert, bioactive materials - temporary fixation devices – joint replacement – biomaterials used in bone and joint replacement metals and alloys- Fillings and restoration materials – Materials for oral and maxillofacial surgery – dental cements and dental amalgams – dental adhesives- bone tissue engineering.

UNIT V APPLICATIONS OF BIO MATERIALS FOR CARDIOVASCULAR OPTHALMOLOGY AND SKIN REGENERATION [10 hours]

Blood clotting – blood theology– approaches to thrombo resistance materials development – blood vessels – The heart – aorta and valves – geometry of blood circulation – cardiac pacemakers – blood substitutes – extracorporeal blood circulation devices.The lungs – vascular implants: vascular graft, cardiac valve prostheses, card– Biomaterials in opthalmology –skin grafts -connective tissue grafts – tissue adhesives – drug delivery methods and materials.

TEXTBOOKS:

1. Sujata V., Bhat., “Biomaterials”, Narosa Publication House, New Delhi, 2002

2. M. V. Gandhi and B. S. Thompson, “Smart Materials and Structures”, Chapman and Hall, London, First Edition, 1992.

REFERENCES:

1. Duerig,T. W., Melton, K. N, Stockel, D. and Wayman, C.M., “Engineering aspects of Shapememory Alloys”, Butterworth – Heinemann, 1990.
2. Rogers, C. A., Smart Materials, “Structures and Mathematical issues”, Technomic Publishing Co., U.S.A, 1989.
3. Mohsen Shahinpoor and Hans-Jo¨rg Schneider “Intelligent Materials”, RSC Publishing,2008
4. Mel Schwartz (Ed), Encyclopaedia of Smart Materials” Volume –I and II, John Wiley & Sons, Inc.2002
5. Buddy D. Ratner (Editor), Allan S. Hoffman (Editor), Frederick J. Schoen (Editor), Jack

E. Lemons, "Biomaterials Science: An Introduction to Materials in Medicine", Academic Press,2nd edition, 2004

DEPARTMENT OF MATERIALS AND METALLUGICAL ENGINEERING
INDUS INSTITUTE OF TECHNOLOGY AND ENGINEERING
INDUS UNIVERSITY

Subject: **Cryogenic Treatment of Materials (EL)**								
Program: **B. Tech in Metallurgical Engineering**				Subject Code: **MME0409**			Semester: **IV**	
Teaching Scheme (Hours per week)				**Examination Evaluation Scheme (Marks)**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	1	0	4	16/40	0	24/60	0	100

Course Objectives

Students are to study and become familiar with this very specialized form of material treatment at low temperature.

UNIT I INTRODUCTION [10 hours]

Insight on Cryogenics-Basics, Properties of Cryogenic fluids, Liquefaction Cycles - Carnot Liquefaction Cycle, F.O.M. and Yield of Liquefaction Cycles. Inversion Curve – Joule Thomson Effect.LindeHampsonCycle, Precooled LindeHampson Cycle, Claude Cycle, Dual Cycle.

UNIT II CRYOCOOLERS [10 hours]

Cryocooler requirement- Satellite communication, Surveillance Imaging, Military applications, Impact of regenerative materials on cooler performance, Impact of material properties on cryocooler performance-Materials used, Thermal Properties, Electrical Properties, and Mechanical properties.

UNIT III CRYOGENIC PROCESSING [10 hours]

Historical Development of Cryogenic Treatment, Cryogenic for Ferrous Metals, Need for cryogenic treatment, Types of low temperature treatment and processors, Benefits of cryogenic treatment-Wear resistance, Stress Relieving, Hardness Precautions during cryogenic treatment.

UNIT IV MATERIALS ENGINEERING [10 hours]

Desirable qualities for materials used in cryogenic applications, History and applications of metallic / non-metallic materials, Understanding properties and fabrication processes of superconducting Nb3Sn wires, High temperature superconductors. Characterization of

cryogenically processed materials.

UNIT V APPLICATIONS [10 hours]

Cryogenic processing of materials for Space applications, Superconductivity, Medical applications, Food Preservation-Individual Quick Freezing, Tool Industry, Automobiles etc.

TEXTBOOK:

1. Randall F. Barron, "Cryogenic Systems", McGraw-Hill, 1985.

REFERENCES:

1. William E. Bryson, "Cryogenics", HanserGardner Publications,1999.
2. Klaus D. Timmerhaus and Richard P. Reed, "Cryogenic Engineering", Springer, 2007.
3. Scott R. B., "Cryogenic Engineering", Van Nostrand and Co., 1962.
4. Jha, A. R., "Cryogenic Technology and Applications", Butterworth-Heinemann, 2006

Subject: **Iron Making**								
Program: **B. Tech in Metallurgical Engineering**				Subject Code: **MME0402**			Semester: **IV**	
Teaching Scheme (Hours per week)				**Examination Evaluation Scheme (Marks)**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	0	2	4	16/40	16/40	24/60	24/60	200

Course Objectives

1. To impart the overall idea of how Iron is produced, the history of Iron making and availability of raw materials for iron production.
2. To know about various techniques of raw material preparation for charging in iron making furnace, construction and operation of iron making furnace and reactions occurring in the furnace, reaction mechanism inside the blast furnace.

CONTENTS

UNIT-I

[10 hours]

General: History of iron making. Occurrence, distribution and evaluation of raw materials (iron ore, coal and flux) for iron making. Burden materials and burden preparation: Burden preparation, Burden qualities. Agglomeration- Sintering-process, variables and machines. Pelletization process, Theory of bonding. Mechanism of ball formation, Disc and drum pelletizer, Induration of pellets, cold bonding technique and testing of pellets.

UNIT-II

[10 hours]

Blast Furnace (B.F.) Constructional features: Profile, Refractories, Accessories, Charging mechanism, Bell and bell-less charging systems. B.F. – Reactions: Physico-chemical principles of blast furnace. Blast furnace reactions. Reaction in stack, tuyere zone, bosh and hearth. Thermodynamics equilibria, Direct and indirect reduction. Kinetics of iron-oxide reduction, Slag-metal reactions, Desiliconization, Desulphurization.

UNIT-III

[10 hours]

B.F. – Operations: Operational steps, Blast furnace irregularities and remedial measures, Blast furnace gas, properties, cleaning and utilization.

UNIT-IV

[10 hours]

Alternative Methods of Iron Making: Reduction smelting, Direct reduction processes, Fluidized bed process, Electro thermal process and mini blast furnace.

Iron Making Lab (List of Experiments)

Experiment No	Title
1	Identification of raw material for iron making
2	Bulk density Measurement
3	Determination of Angle of Repose
4	Sintering of iron ore fines
5	Pelletization of iron ore fines
6	Induration behavior of pellets
7	Box compression test of hardened or indurated pellets
8	Tumbling/Drum test of green and indurated pellets
9	Shatter Test of agglomerated products
10	Drop Test of agglomerated products
11	Study of ISP layout
12	Charge calculations for raw materials in Blast Furnace
13	Study of different parts of Blast Furnace
14	Chemical analysis of Iron based products
15	Study of Briquetting Process

Course Outcomes

1. To apply the knowledge of various types of routes of iron making to practical scenarios.
2. To innovate the existing ideas and ways of making Iron and developing the technology to make this process energy intensive and cost effective.

Text Books

1. R. H. Tupkary, “Introduction to Modern Iron Making”, Khanna Publications, 1st Edition, 2004, ISBN: 9788174090218.

2. A. Ghosh and A. Chatterjee, "Iron Making and Steel Making: Theory and Practice", Prentice Hall, 1st Edition, 2008, ISBN: 9788120332898.
3. A. K. Biswas, "Principles of Blast Furnace Iron Making", SBA Publications, 1st Edition, 1999, ISBN: 9780949917089.

Reference Books

1. A. W. Cramb, "Making, Shaping and Treating of Steels", Association of Iron and Steel Engineers, 11th Edition, 1985, ISBN: 9780930767020.
2. J. G. Peacey and W. G. Davenport, "Blast Furnace: Theory and Practice", Pergamon Press, Oxford, 1st Edition, 1979, ISBN: 9780080232584.
3. J. J. Gupta and Amit Chatterjee, "Blast Furnace Iron Making", SBA Publications, 1st Edition, 1995, ISBN: 9788185164106.

Web Resources

1. NPTEL Course on "Materials and Heat Balance in Metallurgical Processes" (http://nptel.ac.in/courses/113104060/26)

DEPARTMENT OF MATERIALS AND METALLUGICAL ENGINEERING
INDUS INSTITUTE OF TECHNOLOGY AND ENGINEERING
INDUS UNIVERSITY

Subject: **Transport Phenomena**								
Program: **B. Tech in Metallurgical Engineering**				Subject Code: **MME0403**			Semester: **IV**	
Teaching Scheme (Hours per week)				**Examination Evaluation Scheme (Marks)**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	1	2	5	16/40	16/40	24/60	24/60	200

Course Objectives

1. To provide knowledge about the basic concept of heat transfer and its different modes.
2. To analyze different modes of heat transfer with examples in day to day life.
3. To demonstrate the application of various factors & mathematical equations governing the heat transfer in the system.

CONTENTS

UNIT-I

[10 hours]

Fluid flow and its relevance to mass transfer. General mass transport equation. Modes of mass transfer. Film and boundary layer theories. Diffusion, Generalized diffusion equation. Diffusivity in gases, liquids and solids. Steady, diffusion. Pseudo-steady diffusion. Diffusion through porous solids. Convective mass transfer- Mass transfer in fluid at solid-fluid interface. Mass transfer between two fluids. Mass transfer v/s chemical control, enhancement of process rates. Applications in metallurgical system

UNIT-II

[10 hours]

Definition and classification of fluids. Viscosity, Newtonian and non- Newtonian fluids. Viscous and non-viscous fluids. General features of fluid flow. Laminar and turbulent flow, Newton's law of viscosity, Pascal's law.

UNIT-III

[10 hours]

Differential mass balance (continuity equation). Differential momentum balance (equation of motion). Navier Stokes Equation. Application of Differential Balance Equation. Overall mass balance and momentum balance. Euler's equation, Bernoulli's equation. Bernoulli's Equation, Applications of Bernoulli's Equation, Flow through porous media.

UNIT-IV

[10 hours]

Modes of heat transfer. Conduction of heat through solid. Steady and unsteady state. Fourier law of heat conduction. General equation of heat conduction in Cartesian co-ordinate, spherical and cylindrical systems.

Convective heat transfer. Free and forced convection. Application dimensional analysis of effective boundary layer.

Aspects of Radiative Heat Transfer. Reflection, absorption and transmission of radiation. Black body radiation. Planck's Law. Wein's distribution Law. Heat transfer between two bodies by radiation. Lambert's Law.

Transport Phenomena Lab (List of Experiments)

Experiment No.	Title
1	To study about various fluid properties and fluid flows.
2	To determine Reynold's number for fluid flow
3	Measurement of pressure difference using manometers
4	To verify Bernoulli's theorem.
5	To apply Bernoulli's equation to Venturimeter
6	To apply Bernoulli's equation to Orificemeter
7	To study the fundamentals of heat transfer
8	To determine thermal conductivity of insulating powder using sphere in sphere method.
9	To measure overall heat transfer coefficient for given composite wall with help of composite wall apparatus.
10	To determine temperature distribution and the effectiveness of fin.
11	To determine the surface heat transfer coefficient for a vertical tube losing heat by natural convection.
12	To determine convective heat transfer coefficient in force convection
13	To determine Stefan-Boltzmann constant
14	To determine emissivity for the given surface
15	Study of mass transfer

Course Outcomes

1. To solve different numerical pertaining to all three modes of heat transfer for different systems.

2. To demonstrate the phenomena of conduction, convection & Radiation by conducting laboratory scale experiments.
3. To make the students understand the concept of fluid behavior & its relevance for different modes of mass transfer.
4. To analyze the mass & momentum balance equations to understand the diffusion phenomenon in metallurgical systems.

Text Books

1. A. K. Mohanty, "Rate Processes in Metallurgy", Prentice Hall India Learning Private Limited, 3rd Edition, 2009, ISBN: 9788120335912.
2. V. Gupta, "Elements of Heat and Mass Transfer", New Age International Publishers, 1st Edition, 1995, ISBN: 9788122408003.
3. J. H. Szekely and N. J. Themelis, "Rate Phenomena in Process Metallurgy", John Wiley & Sons, 1st Edition, 1971, ISBN: 9780471843030.
4. D. R. Poirier and G. H. Geiger, "Transport Phenomena in Materials Processing", John Wiley & Sons, 1st Edition, 1998, ISBN: 9780873392723.

Reference Books

1. R. B. Bird, W. E. Stewart and E. N. Lightfoot, "Transport Phenomena", Wiley, 2ndEdition, 2006, ISBN: 9788126508082.
2. M. Iguchi and O. J. Ilegbusi, "Basic Transport Phenomena in Materials Engineering", Springer Nature, 1st Edition, 2014, ISBN: 9784431540199.
3. D. R. Gaskell, "An Introduction to Transport Phenomena in Materials Engineering", Momentum Press, 2nd Edition, 2012, ISBN: 9781606503553.
4. J. Welty, C.E. Wicks, G.L. Rorrer and R.E. Wilson, "Fundamentals of Momentum, Heat and Mass Transfer", John Wiley & Sons, 5th Edition, 2012, ISBN: 9780470128688.
5. F. P. Incropera, D. P. Dewitt and T. L. Bergman, "Fundamentals of Heat and Mass Transfer".
6. Y. A. Cengel and A. J. Ghajar, "Heat and Mass Transfer".

Web Resources

1. NPTEL MOOC Course on "Transport Phenomena"
(https://onlinecourses.nptel.ac.in/noc17_ch11/preview)
2. SWAYAM MOOC Course on "Transport Phenomena"
(https://swayam.gov.in/course/3719-transport-phenomena)
3. EdX Online Course on "The Basics of Transport Phenomena"
(https://courses.edx.org/courses/course-v1:DelftX+TP101x+1T2017/info)
4. EdX Online Course on "Advanced Transport Phenomena"
(https://courses.edx.org/courses/course-v1:DelftX+TP102x+3T2016/info)

DEPARTMENT OF MATERIALS AND METALLUGICAL ENGINEERING
INDUS INSTITUTE OF TECHNOLOGY AND ENGINEERING
INDUS UNIVERSITY

Subject: **Heat Treatment Principles and Practices**								
Program: **B. Tech in Metallurgical Engineering**				Subject Code: **MME0404**			Semester: **IV**	
Teaching Scheme (Hours per week)				**Examination Evaluation Scheme (Marks)**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	0	2	4	16/40	16/40	24/60	24/60	200

Course Objectives

1. To introduce the engineering science principles and applications associated with heat treatments.
2. To study the basic heat treatment processes.
3. To study the structure of metals and its influence on material properties and performance based on different heat treatments.

CONTENTS

UNIT-I

[10 hours]

Principles of heat treatment of steels:

Phase Transformation on heating, Forming of austenite, Kinetics of formation of austenite, Nucleation sites in eutectoid steels, Austenitic grain size, Grain growth, Determination of austenitic grain size, Importance of austenitic grain size

TTT (Time Temperature Transformation) and CCT (Continuous Cooling Transformation) diagrams:

Method of plotting, Types of TTT diagram, Critical cooling rate, Effect of alloying elements on TTT diagram, Applications, Continuous cooling transformation diagram, Limitations of Iron-Iron Carbide Diagram, Effect of Alloying elements on CCT diagram.

UNIT-II

[10 hours]

Pearlitic transformation: Mechanism of transformation, Kinetics of transformation, Hull-Mehl model of pearlitic transformation, Effect of alloying elements on transformation, Interlameller spacing,

Bainitic transformation: Characteristics, Mechanism of transformation, Bainitic structure.

Martensitic transformation:

Diffusionless transformation, Mechanism of transformation, Kinetics of transformation, M_s - M_f temperatures, Athermal and isothermal martensites, Effect of applied stress on transformation, Habit planes, Bain distortion model / crystallographic theory of martensitic transformation,

Tempered Martensite, Retained austenite, Martensitic transformation in non-ferrous systems such as Fe-Ni and Cu-Al systems.

UNIT-III

[10 hours]

Heat treatment processes:

Stress relieving, Annealing – full annealing, partial annealing, bright annealing, diffusion annealing, recrystallization annealing, Spheroidizing, Normalizing, Hardening and Tempering, Hardening of typical steels, cast irons and non-ferrous alloys.

Surface hardening of metals:

Principles involved in induction and flame hardening methods and application of selective hardening, Laser hardening, Case carburizing (solid, liquid and gaseous), Cyaniding, Carbonitriding, Nitriding, Plasma nitriding etc., Depth of penetration - its measurement and relation with time and temperature, Hardening & Hardenability of steels.

UNIT-IV

[10 hours]

Special methods of heat treatment:

Austempering, Martempering, Ausforming, Patenting, Sub-zero treatment etc., Thermo Mechanical treatments. Heat treatment of carbon steels, alloy steels, tools and dies steels, stainless steels (with reference to carbide precipitation and sigma phase formation) and cast irons – specific examples, Heat treatment of Aluminum alloys, titanium alloys and copper alloys, Concept of age-hardening. Design for heat treatment, Heat treatment furnaces- their temperature and atmosphere control, Defects in heat treated parts, Causes for the defects in heat-treated parts and remedies.

Heat Treatment Principles and Practices Lab (List of Experiments)

Experiment No.	Title
1	Annealing of Medium / High carbon steels
2	Characterization of annealed steel
3	Normalizing of Medium / High carbon steels
4	Characterization of normalized steel
5	Spheroidizing of High carbon steel
6	Characterization of spheroidized steel
7	Hardening of medium/ high carbon steels
8	Characterization of hardened steel

9	Tempering of medium/ high carbon steels
10	Characterization of tempered steel
11	To examine the effect of quenching media on hardening of steel
12	To measure the hardenability of steel using Jominy End-Quench test
13	To study the case hardening processes
14	Carburizing of low carbon steels
15	Case depth measurement and characterization of carburized steels

Course Outcomes

1. To apply the knowledge of various types of heat treatments to design the heat treatment cycles for different components of many areas of mechanical, manufacturing, civil, and materials engineering in the aerospace, automobile, transportation, energy, environmental, biomedical, and electronics industries.
2. To predict the mechanical properties based on the changes in heat treatment variables.
3. To apply their knowledge in the field of alloy design and microstructural engineering.

Text Books

1. D. S. Clark and W. R. Varney, "Physical Metallurgy for Engineers", Van Nostrand Reinhold Company, 2nd Edition, 1962, ISBN: 9780442015701.
2. T. V. Rajan, C. P. Sharma and A. Sharma, "Heat Treatment (Principles and Techniques)", Prentice Hall India, 2nd Edition, 2011, ISBN: 9788120340954.

Reference Books

1. S. H. Avner, "Physical Metallurgy", Tata Mcgraw –Hill, 2nd Edition, 2008, ISBN: 9780074630068.
2. Y. Lakhtin, "Engineering Physical Metallurgy", CBS Publishers & Distributors, 1st Edition, 2005, ISBN: 9788123906027.
3. S. H. Avner, "Physical Metallurgy", Tata Mcgraw –Hill, 2nd Edition, 2008, ISBN: 9780074630068.
4. V. D. Kodgire and S. V. Kodgire, "Material Science and Metallurgy for Engineers", Everest Publishing House, 31st Edition, 2011, ISBN: 9788186314005.
5. V. Singh, "Heat Treatment of Metals", Standard Publishers Distribution, 2nd Edition, 2011, ISBN: 9788180140389.
6. V. Raghvan, "Physical Metallurgy (Principles and Practice)", Prentice Hall India, 2nd Edition, 2006, ISBN: 9788120330122.
7. B. Zakharov, "Heat Treatment of Metals", University Press of the Pacific, 2nd Edition, 2002, ISBN: 9781410203052.
8. ASM International, "ASM Handbook on Heat Treating Vol. 4", 11th edition, 1991, ISBN: 9780871703798.
9. K. H. Prabhudev, "Handbook of Heat Treatment", Tata Mc-Graw Hill, 4th Reprint, 2011, ISBN: 9780074518311.

Web Resources

1. NPTEL Course on "Principles of Physical Metallurgy" (http://nptel.ac.in/courses/113105024/)
2. NPTEL MOOC Course on "Heat Treatment and Surface Hardening-I" (https://onlinecourses.nptel.ac.in/noc16_mm12/preview)
3. NPTEL MOOC Course on "Heat Treatment and Surface Hardening-Part II" (https://onlinecourses.nptel.ac.in/noc17_me19/preview)

DEPARTMENT OF MATERIALS AND METALLUGICAL ENGINEERING
INDUS INSTITUTE OF TECHNOLOGY AND ENGINEERING
INDUS UNIVERSITY

Subject: **Metal Casting and Solidification (OE – 4)**								
Program: **B. Tech in Metallurgical Engineering**				Subject Code: **MME0405**			Semester: **IV**	
Teaching Scheme (Hours per week)				**Examination Evaluation Scheme (Marks)**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	0	0	3	16/40	0	24/60	0	200

Course Objectives

1. To acquire the knowledge about the fundamentals of the casting, basic terminology related to casting process.
2. To make students aware about the alternative method for the manufacturing of component for engineering applications.

CONTENTS

UNIT-I

[10 hours]

Moulding materials: Properties, preparation & testing:
Functional requirements of moulding materials, moulding practice & special requirements of core sands, foundry sands & binders, sand preparation & systems, silica programme.

UNIT-II

[10 hours]

Production techniques:
Manufacture of sand castings, mould production, moulding techniques, cores & core making, melting & casting, finishing operation. Shell, investment and die casting process, centrifugal casting, other special techniques.

UNIT-III

[10 hours]

Liquid metals and gating & feeding of castings:
Fluidity of liquid metals, mould factors in metal flow, the gating of casting. The feeding characteristics of alloys, methods for feeding of castings; design modifications, padding chills & insulation, the feeding of cast irons, solidification modeling.

UNIT-III

[10 hours]

Casting design and analysis of casting defects:
Preliminary stages & production stages, process & alloy selection, physical design features, quality assessment & control. Categories of defects, gas defects, shrinkage defects, contraction defects, compositional errors & segregation, inclusions & sand defects, shaping faults.

Course Outcomes
1. To apply knowledge about how to manufacture the intricate casting what should be the process parameter, design of pattern, mould, etc.
2. To apply the theory about the melting practice of different cast alloy.
3. To apply the knowledge to overcome defects generated during casting.

Text Books
1. R. W. Heine, C. R. Loper and P. C. Rosenthal, "Principles of Metal Casting", Tata McGraw Hill, 2nd Edition, 2017, ISBN: 9780070993488.
2. P. L. Jain, "Principles of Foundry Technology", Tata McGraw Hill, 2nd Edition, 1987, ISBN: 9780074516980.

Reference Books
1. P. C. Mukherjee, "Fundamentals of Metal Casting Technology", Oxford & IBH, 1st Edition, 1988, ISBN: 9788120403635.
2. P. R. Beeley, "Foundry Technology", Butterworth-Heinemann, 2nd Edition, 2001, ISBN: 9780750645676.
3. H. F. Taylor and M. C. Flemings, "Foundry Engineering", Wiley Eastern, 1st Edition, 1959, ISBN: 9780471848431.
4. D. Kumar and S. K. Jain, "Foundry Technology", CBS Publications, 1st Edition, 2007, ISBN: 9788123902906.

Web Resources
1. NPTEL MOOC Course on "Principles of Casting Technology"
(https://onlinecourses.nptel.ac.in/noc17_me11/preview)

DEPARTMENT OF MATERIALS AND METALLUGICAL ENGINEERING
INDUS INSTITUTE OF TECHNOLOGY AND ENGINEERING
INDUS UNIVERSITY

Subject: **Recycling of Materials (OE – 5)**								
Program: **B. Tech in Metallurgical Engineering**				Subject Code: **MME0406**			Semester: **IV**	
Teaching Scheme (Hours per week)				**Examination Evaluation Scheme (Marks)**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	0	0	3	16/40	0	24/60	0	100

Course Objectives

1. To make the students aware about the serious issue and how to combat the problem.
2. Classifications of the waste materials, recycling methods, recycling symbol and the technology of recycling within the economic barriers will be dealt with in this course.
3. Students will learn how to make public conscious of recycling of wastes and economic consideration.

CONTENT

UNIT-I

[10 hours]

Definition of terms, recycling and recovery.

Importance, purpose, and contribution of economy and human and environmental health of recycling. Recycling symbols, Recyclable wastes. Recycling statistics in India and World.

UNIT-II

[10 hours]

Defining the stages of recycling processes.

Collection, Separation and recycling stages of plastic wastes, steel/stainless steel, aluminum, and copper wastes, and recycling symbols.

UNIT-III

[10 hours]

Collection, Separation and recycling stages of composite wastes, glass wastes, building wastes, and recycling symbols.

UNIT-IV

[10 hours]

Collection, Separation and recycling stages of accumulator and battery wastes, electronic wastes, and recycling symbols.

Collection, transportation and disposal of harmful wastes.

Course Outcomes

1. The students will be made familiar with different types of waste materials and their disposal problems. Thus, necessitating the knowledge on recycling of the waste materials.
2. Distinguish the recycling, recovery, reuse, reduce and disposal of wastes.
3. Comprehend the recycling symbols.
4. The students will be able to know about the collection and separation systems of wastes.
5. The students will be able to analyses awareness studies to public.

Reference Books

1. Material Recycling – Trends and perspectives, Edited by Dimitris S. Achilias, InTech, 2012.

5TH SEMESTER

Subject: **Steel Making**								
Program: **B. Tech in Metallurgical Engineering**				Subject Code: **MME0501**			Semester: **V**	
Teaching Scheme (Hours per week)				**Examination Evaluation Scheme (Marks)**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	0	0	3	16/40	0	24/60	0	100

Course Objectives

1. To impart the overall idea of how Steel is produced the history of Steel making.
2. To know about various techniques of raw material preparation for charging in iron making furnace, construction and operation of iron making furnace and reactions occurring in the furnace, reaction mechanism inside the blast furnace and post treatment to make steel.

CONTENTS

UNIT-I

[10 hours]

General:

Old Steel Making practices. Modern equipment and practices. Integrated Steel Plants in India. Mini steel plants their advantages and limitations – present scenario.

Physical Chemistry of Steel Making:

Thermodynamic and Kinetics of Refining Reactions, Carbon, Phosphorus, Sulphur and Silicon Reactions. Refining Slag and its Properties. Importance and Mechanism of decarburization. Reaction at Slag Metal interface.

UNIT-II

[10 hours]

Basic Oxygen Steel Making:

BOF practice, Equipment, Operation and Process, slag Metal reactions in B.O.F. Raw material and flux practices. Kaldo, OBM, LD-AC, Rotor process, Top and Bottom blowing processes. **Oxygen Lance:**

Design, Construction and Operation. Top and Bottom Blown processes, Its advantages and disadvantages

Electric Steel Making:

Induction Furnace, Electric Arc Furnaces: Types and construction. Sequence of operations. Various additions at Different Stages, Slag Control. UHP Arc Furnaces. Arc Furnace practices for Carbon and Low Alloy Steels. Modern developments in ARC furnaces.

UNIT-III

[10 hours]

Quality Steel Making:

Introduction, Sources of Inclusions, Sulphur, Phosphorus, and Gases in Steels. Kinetics of Deoxidation of Molten Steel, Application of Ellingham Diagrams, Thermodynamics of Reaction During Degassing of Liquid Steel, Fluid Flow and Mixing in Ladle, Kinetics and Mass Transfer, Ladle Injection Metallurgy, Desulphurization & Dephosphorization.

Secondary Steel Making:

Metallurgical Principles in Secondary Steel Making and Secondary Steel Making Processes. Ladle Furnaces (L.F.), Vacuum Systems and Vacuum treatment of Steel. Removal of Gases from steel. LF-VD processes and AOD, VOD, VAD techniques, R-H degassers. Ladle Stirring and its Advantages. ESR Principle And Technology. Deoxidation – Theory and practice, Floatation's of deoxidation products, Modifications of Inclusions. Injection Metallurgy

UNIT-IV

[10 hours]

Inclusions in Steel:

Influence of Inclusions on Mechanical Properties of Steel, Inclusion, Identification and Cleanness Assessment, Origin of Non Metallic Inclusions, Inclusion Control Continuous Casting **(C.C.) and Ingot Casting:**

6 Hrs Ingot Casting: Types of Moulds, Advantages and Disadvantages. Ingot Defects and Remedies. Continuous casting: C.C. machines with its various units and types. C.C. of Blooms, Slabs and Thin slabs EM S of Moulds. Reoxidation prevention methods during Steel Casting. Advantage of C.C. Environmental issues related to Steel Making, Heat Transfer & Solidification Rate in Ingot Casting and Continuous Casting, Distinguishing Metallurgical Aspects of Continuous Casting of Steel.

Course Outcomes

1. To apply the knowledge of various types of routes of iron making to practical scenarios.
2. To innovate the existing ideas and ways of making Iron and developing the technology to make this process energy intensive and cost effective.

Text Books

1. R. H. Tupkary, "An Introduction to Modern Steel Making", Khanna Publishers, 7th Edition, 2000, ISBN: 9788174090263.
2. G. R. Bashforth, "The Manufacture of Iron and Steel: Vol I", Chapman & Hall, 3rd Edition, 1964, OCLC: 439659739.

3. G. R. Bashforth, "The Manufacture of Iron and Steel: Vol II", Nabu Press, Primary Source Edition, 1964, ISBN: 9781295841929.

Reference Books

1. A. W. Cramb, "Making, Shaping and Treating of Steels", Association of Iron and Steel Engineers, 11th Edition, 1985, ISBN: 9780930767020.
2. R. G. Ward, "An Introduction to the Physical Chemistry of Iron and Steel Making", Edward Arnold Ltd, 1st Edition, 1962, ASIN: B0007IZZGY.
3. V. A. Kudrin, "Steel Making", Mir Publisher, 1st Edition, 1985, ASIN: B0007BN3H4.
4. A. K. Ghosh and A. Chatterjee, "Iron and Steel Technology".
5. E. T. Turkdogen, "Fundamentals of Steel Making".

Web Resources

1. NPTEL MOOC Course on "Steel Quality: Role of Secondary Refining & Continuous Casting" (https://onlinecourses.nptel.ac.in/noc17_mm10/preview)

Subject: **Non Ferrous Extractive Metallurgy**								
Program: **B. Tech in Metallurgical Engineering**				Subject Code: **MME0502**			Semester: **V**	
Teaching Scheme (Hours per week)				**Examination Evaluation Scheme (Marks)**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	0	0	3	16/40	0	24/60	0	100

Course Objectives

1. To make the students aware about basics of non-ferrous metals and its extraction processes.
2. To impart the knowledge about the basic steps followed in extraction and their importance.

CONTENTS

UNIT-I

[10 hours]

General:

World resources of Non-ferrous metals and their occurrence. Present and future position of non-ferrous metallurgical industry in India- resources, production and consumption.

Indian scenario of non-ferrous ores and mineral deposits. Production plants for non-ferrous metals such as copper, zinc, lead, tin, Aluminum, nickel, magnesium, titanium, etc.

Basics of Pyrometallurgy, Hydrometallurgy and electrometallurgy

UNIT-II

[10 hours]

Aluminum:

Occurrence of Bauxite. Bayer's process for production of alumina. Alternatives to Bayer's process. Hall-Heroult process-conventional and new materials for construction of Aluminum reduction cell, nature of electrolyte. Electrolysis of alumina with emphasis on physico-chemical principles and secondary-reactions, factors affecting current efficiency. Alternatives to Hall-Heroult process. Refining of Aluminum.

Copper:

Occurrence of copper ores. Roasting. Matte-smelting, Converting and Refining process as applied to copper production and their physico-chemical aspects. Single step and multistep continuous processes. Hydrometallurgical process for production of primary copper. Recovery of copper from copper slag.

UNIT-III

[10 hours]

Nickel:
Occurrence of nickel ores, Pyrometallurgical and Hydrometallurgical processes for nickel production and refining.

Lead and Zinc:
Occurrence of lead and zinc ores, Pyrometallurgical and Hydrometallurgical processes for lead and zinc production and their physio-chemical aspects, Refining of lead and zinc, Recovery of byproducts.

Tin:
Occurrence of tin, various methods of extraction of tin from its ores and other sources. Uses of tin.

UNIT-IV

[10 hours]

Gold and Silver:
Occurrence of gold and silver. Various methods for production of gold and silver from their ores and other sources.
Recovery of gold, silver and platinum from secondary sources such as Copper Anode Mud, Red Mud, Zinc dross and electrolytic solutions.

Magnesium:
Occurrence of magnesium, Methods of production of magnesium oxide and magnesium chloride, Pyrometallurgical extraction of magnesium, Electrolytic extraction and refining of magnesium.

Titanium
Occurrence of titanium, Extraction, Production, recovery, properties and application.

Course Outcomes

1. To apply the knowledge regarding the auxiliary operation and the advancement in various extractive process.
2. To apply the theory about the extraction practice of different non-ferrous metals.

Text Books

1. H.S. Ray, R. Sridhar and K.P. Abraham, “Extraction of Nonferrous Metals”, Affiliated East West Press Pvt Ltd, 1st Edition, 2008, ISBN: 9788185095639.

Reference Books

1. W. H. Dennis, “Extractive Metallurgy”, Pitman Publishing, 1st Edition, 1965, ISBN: 9780273404729.
2. F. Habashi, “Principles of Extractive Metallurgy”, Gordon & Breach, 1st Edition, 1970, ISBN: 9780677017808.

3. T. Rosenqvist, "Principles of Extractive Metallurgy", McGraw Hill, 1st Edition, 1974, ISBN: 9780070538474.
4. J. L. Bray, "Nonferrous Production Metallurgy", John Wiley and Sons, 2nd Edition, 1947, ASIN: B0007E2TW6.
5. R. D. Pehlke, "Unit Processed in Extractive Metallurgy", Elsevier, 1st Edition, 1973, ISBN: 9780444001306.
6. H. S. Ray, "Introduction to Melts: Molten Salts, Slags and Glasses", Allied Publishers Pvt Ltd 1st Edition, 2006, ISBN: 9788177648751.
7. H.S. Ray, B.P Singh, S. Bhattacharjee and V. N. Misra, "Energy in Minerals and Metallurgical Industries", Allied Publishers Pvt Ltd, 1st Edition, 2005, ISBN: 8177648748.
8. H. S. Ray and A. Ghosh, "Principles of Extractive Metallurgy", New Age Publishers, 2nd Edition, 1991, ISBN: 9788122403220.

Web Resources

1. NPTEL Course on "Non-Ferrous Extractive Metallurgy"
(http://nptel.ac.in/courses/113105021/)

DEPARTMENT OF MATERIALS AND METALLUGICAL ENGINEERING
INDUS INSTITUTE OF TECHNOLOGY AND ENGINEERING
INDUS UNIVERSITY

Subject: **Plastic Deformation of Metals**								
Program: **B. Tech in Metallurgical Engineering**				Subject Code: **MME0503**			Semester: **V**	
Teaching Scheme (Hours per week)				**Examination Evaluation Scheme (Marks)**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	1	0	4	16/40	0	24/60	0	100

Course Objectives

1. To provide knowledge about the basic concept crystals their structures and their defects that is point, line, volume and surface defects.
2. To teach them basics about dislocations and how dislocations help in improving properties.
3. To teach them various strengthening mechanism of metals.

CONTENTS

UNIT-I

[10 hours]

Crystal Imperfections, Point Defects, Line Defects & Surface Defects, Dislocation and its types, Slip Phenomena, Slip Systems. Theoretical strength of a perfect Crystal, Slip by dislocation movement concept of critical resolved shear stress, Climb and its types, Twinning as a mode of deformation, Burgers vector and the dislocation loop, Stress fields and energies of dislocations, Jogs and Kinks.

UNIT-II

[10 hours]

Dislocation in F.C.C (including formation of stacking fault.) B.C.C and H.C.P., Forces. Multiplication of dislocations, Techniques to observe dislocation, Dislocation point defects interactions, Intersection of Dislocations, Dislocations pile up.

Deformation of single and polycrystalline materials, Grain boundaries. Low-angle boundaries, High Angle Grain Boundaries Surface tension of the grain boundary, Strengthening from grain boundaries, Hall-petch equation, Yield point phenomenon.

UNIT-III

[10 hours]

Strain- hardening of polycrystalline metals, Strain hardening of single crystals, Relation between single and polycrystalline stress-strain curve, Solid – Solution hardening. Strengthening due to second phase particles, Strain – ageing behavior, annealing of cold-worked metals, Recovery, Recrystallization and grain growth.

All types of tests, Modes of Failure, Theory of ductile-brittle transition temperature (DBTT).

UNIT-IV

[10 hours]

Types of fracture in metals. Theoretical cohesive strength of metals. Griffith theory of brittle fracture, Elementary concept of fracture mechanics, Fatigue test. Theory of fatigue. Effect of metallurgical variables and temperature. Creep test, Creep curve. Stress-rupture test, Creep mechanisms. High temperature alloys. Effect of some metallurgical variables. Presentation of engineering creep data.

Course Outcomes

1. To solve different numerical pertaining to resolved shear stress and hall pitch equation.
2. To apply the concepts of fracture mechanics like ductile and brittle fracture.
3. To apply the theory about testing, creep and fatigue testing in practice.
4. To solve practical example on the testing.

Text Books

1. G. E. Dieter, "Mechanical Metallurgy", McGraw-Hill, 3rd Edition, 2013, ISBN: 9781259064791.
2. R. Abbaschian, L. Abbaschian and R. E. Reed-Hill, "Physical Metallurgy Principles", Stamford CT: Cengage Learning, 4th Edition, 2010, ISBN: 9780495438519.
3. R. W. Hortzberg, "Deformation and Fracture Mechanics of Engineering Materials", John Wiley and Sons, 5th Edition, 2012, ISBN: 9780470527801.
4. J. Wulff, H. W. Hayde and W. I. Moffatt, "Structure and Properties of Materials Vol.III: Mechanical Behaviour", John Wiley and Sons, 1st Edition, 1967, ASIN: B000N91X72.

Reference Books

1. T. H. Courtney, "Mechanical Behavior of Materials", Waveland Pr Inc, 2nd Edition, 2005, ISBN: 9781577664253.
2. A. V. K. Suryanarayan, "Testing of Metallic Materials", BS Publications, 1st Edition, 2007, ISBN: 9788178001340.

Web Resources

1. NPTEL MOOC Course on "Introduction to Crystal Elasticity and Crystal Plasticity" (https://onlinecourses.nptel.ac.in/noc16_mm13/preview)
2. EdX Online Course on "Mechanical Behavior of Materials" (https://courses.edx.org/courses/MITx/3.032x/3T2014/info)
3. NPTEL MOOC Course on "Fundamentals of Material Processing - I" (https://onlinecourses.nptel.ac.in/noc17_mm09/preview)
4. NPTEL MOOC Course on "Fundamentals of Material Processing - I" (https://onlinecourses.nptel.ac.in/noc16_mm11/preview)
5. EdX Online Course on "Fundamentals of Manufacturing Processes" (https://www.edx.org/course/fundamentals-manufacturing-processes-mitx-2-008x)

DEPARTMENT OF MATERIALS AND METALLUGICAL ENGINEERING
INDUS INSTITUTE OF TECHNOLOGY AND ENGINEERING
INDUS UNIVERSITY

Subject: **Foundry Technology**								
Program: **B. Tech Metallurgical Engineering**				Subject Code: **MME0504**			Semester: **V**	
Teaching Scheme (Hours per week)				**Examination Evaluation Scheme (Marks)**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	0	2	4	16/40	16/40	24/60	24/60	200

Course Objectives

1. To acquire the knowledge about the fundamentals of the casting, basic terminology related to casting process.
2. To make students aware about the alternative method for the manufacturing of component for engineering applications.

CONTENTS

UNIT-I

[10 hours]

General: Introduction to metal casting and foundry industry in modern industrial scenario. Advantages and limitations of casting methods. Classification of foundries. Different sections in a foundry and their functions. Important cast metals and alloys-their composition, properties and uses.

Patternmaking: Patterns. Types. Pattern making materials and their selection, Color code, Pattern allowances, Core-boxes and their types.

UNIT-II

[10 hours]

Moulding and Core-making Materials: Ingredients of common type of moulding and core-making sands, their properties and behavior, testing of sands and clay.

Moulding Processes: Classification, Brief description of processes such as green sand, dry sand, loam, floor, Pit and machine molding. No-bake molding process. CO_2-Silicate process.

UNIT-III

[10 hours]

Casting Processes: Shell molding and casting process, Investment casting process, Permanent molding process. Gravity and Pressure Die-casting, Centrifugal casting process. Low Pressure Die-casting (LDPC) process.

Melting: Melting of cast iron, Constructional features of Cupola, Principles and operation of Cupola furnace. Advances in cupola melting operation, Principles of Induction furnace, Melting of aluminum and Copper-based alloys. Furnaces used, Melt-treatments such as degassing, Grain refining and modification.

UNIT-IV

[10 hours]

Gating System: Elements of gating system. Classification. Gating design considerations, Gating ratio. Gating practice for ferrous and non-ferrous alloys, Pouring equipments.

Risering System: Risering practice, Functions of riser, Directional and progressive solidification. Centerline feeding resistance. Riser efficiency. Riser design considerations. Risering curves. Cain's, N.R.L. and Modulus methods, feeding distance and feeding aids, Blind and atmospheric risers

Quality Control in Foundry: Casting defects, their causes and remedies. Shop floor quality control tests such as composition control, Wedge test, fluidity, temperature measurement etc. Salvaging and Repairing of Castings

Foundry Technology Lab (List of Experiments)

Experiment No.	Title
1	Introduction to foundry laboratory.
2	To detrmine AFS fineness number and distribution coefficient of agiven sand sample
3	To demonstrate the working of sand muller
4	To determine the clay content of given sand sample
5	To prepare standard samples under identical condition for checking important physical properties of foundry sand
6	To determine compression strength of foundry sand
7	To determine permeability number of green sand,core sand and raw sand
8	To find out the green mould hardness of the sand mould
9	To determine shatter index of the sand sample.
10	To determine moisture content of the prepared sand
11	To prepare core sand
12	To findout the hardness of dried cores made out of core sands
13	To perform peelback test on core sand

14	To perform hot distortion and tensile tests on core sand
15	To study the aluminum melting and casting

Course Outcomes

1. To apply knowledge about how to manufacture the intricate casting what should be the process parameter, design of pattern, mould, etc.
2. To apply the theory about the melting practice of different cast alloy.
3. To apply the knowledge to overcome defects generated during casting.

Text Books

1. R. W. Heine, C. R. Loper and P. C. Rosenthal, "Principles of Metal Casting", Tata McGraw Hill, 2nd Edition, 2017, ISBN: 9780070993488.
2. P. L. Jain, "Principles of Foundry Technology", Tata McGraw Hill, 2nd Edition, 1987, ISBN: 9780074516980.

Reference Books

1. P. C. Mukherjee, "Fundamentals of Metal Casting Technology", Oxford & IBH, 1st Edition, 1988, ISBN: 9788120403635.
2. P. R. Beeley, "Foundry Technology", Butterworth-Heinemann, 2nd Edition, 2001, ISBN: 9780750645676.
3. H. F. Taylor and M. C. Flemings, "Foundry Engineering", Wiley Eastern, 1st Edition, 1959, ISBN: 9780471848431.
4. D. Kumar and S. K. Jain, "Foundry Technology", CBS Publications, 1st Edition, 2007, ISBN: 9788123902906.

Web Resources

1. NPTEL MOOC Course on "Principles of Casting Technology" (https://onlinecourses.nptel.ac.in/noc17_me11/preview)

DEPARTMENT OF MATERIALS AND METALLUGICAL ENGINEERING
INDUS INSTITUTE OF TECHNOLOGY AND ENGINEERING
INDUS UNIVERSITY

Subject: **Fuels Furnaces and Refractories (EL–1)**								
Program: **B. Tech in Metallurgical Engineering**				Subject Code: **MME0505**			Semester: **V**	
Teaching Scheme (Hours per week)				**Examination Evaluation Scheme (Marks)**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	0	0	3	16/40	0	24/60	0	100

Course Objectives

1. To understand use of fuels and refractories in the different levels of the operational systems.
2. To co-relate the basic of the mechanical and high temperature properties and individual response and related over all logical changes and uses of the respective materials.
3. To develop creativity for Pyro- Research.
4. To know various considerations like laws of physics, chemistry and also factors of safety etc.

CONTENTS

UNIT-I

[10 hours]

Fuels: Classification of fuels, solid, liquid and gaseous fuel-their advantages and limitations, Comparative study of solid, liquid and gaseous fuels, Combustion of fuels, Combustion characteristics of fuel, Analysis and testing of fuels, Carbonization of coal-coke making and by products, producer gas, water gas, natural gas, LPG, Blast Furnace gas, Coke oven gas, LD gas, storage of Fuels in transport, nuclear fuel, other energy resources such as Solar, Wind, Geothermal, Bio-mass, Hydrogen, Nuclear Energy.

UNIT-II

[10 hours]

Furnaces and Furnace Design: Classification based on heating methods, application wise and temperature ranges, Batch furnaces, continuous furnaces, Construction and working of furnaces like Cupola, Induction Furnace, Electric Arc Furnace, Resistance Furnace, Pit furnace, Rotary Furnace, Muffle Furnace, Modern furnaces: plasma heating Furnace accessories (Burners, blowers, pumps, chimneys, drafts), thermal interactions in furnace, furnace atmosphere, heat economics, Furnace capacity and efficiency along with factors affecting it. Related numericals.

UNIT-III

[10 hours]

Refractories:

Introduction, concept of Refractoriness, requirements of good refractory material, classifications, types of the refractories and their individual manufacturing processes, Refractory properties,

Testing and related machineries and how to control those machineries, a comparative study of the ternary phase diagram of different types of refractories, Details of Blast furnace refractory and LD Converters of Ladles, Castable refractory – preparation, fabrication and uses, Supper Refractories and their uses. Refractories numerical.

UNIT-IV

[10 hours]

Pyrometry:

Basic concept of temperature measurement and control, Stefan's Boltzmann's theory and related ideas in temperature measurement, Thermometry, resistance thermometer - principle, constructional details, applications, Principle of thermocouple, construction and calibration of thermocouple, Different types of thermocouple for measurement of various temperature ranges, Optical Pyrometer and Radiation Pyrometer – Principle, construction, working principle, advantages, comparative study of Optical Pyrometer and Radiation Pyrometer

Course Outcomes

1. To apply the knowledge of various types of high temperature changes and also the mode of fabrication for such changes used in the research areas and how to design those operations.
2. To predict effectively and accurately the reasons of faults related to temperature and then correlate how to rectify.
3. To apply the basic principles, working principles laws, related details, graphical details, applications and also a comparison study with each other.

Text Books

1. O. P. Gupta, "Elements of Fuels, Furnaces and Refractories", Khanna Publishers, 2nd Edition, 2002, ISBN: 9788174090881.

Reference Books

1. J. D. Gilchrist, "Fuels, Furnaces and Refractories", Pergamon, 2nd Edition, 2013, ISBN: 9781483151977.
2. W. Trinks, M. H. Mawhinney, and R. A. Shannon, "Industrial Furnaces", John Wiley & Sons, 6th Edition, 2004, ISBN: 9780471387060.
3. Charles E. Baukal Jr., "The John Zink Combustion Handbook".

Web Resources

1. NPTEL Course on "Fuels Refractory and Furnaces"
(http://nptel.ac.in/courses/113104008/)

Subject: **Environmental Pollution and Control in Metallurgical Industries (EL–1)**								
Program: **B. Tech in Metallurgical Engineering**				Subject Code: **MME0506**				Semester: **V**
Teaching Scheme (Hours per week)				**Examination Evaluation Scheme (Marks)**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	0	0	3	16/40	0	24/60	0	100

Course Objectives

1. To understand the sources of Air pollution.
2. To understand the various effects of pollution on human health, vegetables etc.

CONTENTS

UNIT-I

[10 hours]

Introduction: Definition, air pollution episodes, general nature of air pollution problems
Air Pollutants, Sources & their inventory: Particulate matter, carbon dioxide, carbon Monoxide, sulphur oxide, effects of hydrocarbon, oxide of nitrogen, photochemical oxidants, asbestos and metals on materials and health.

UNIT-II

[10 hours]

Effects of Air Pollution: Effects of air pollution on human, vegetation, animals and Materials.
Meteorology: Introduction, solar radiation, wind circulation, lapse rate, stability conditions, wind velocity profile maximum mixing depth, wind rose turbulence, and general characteristics of plumes, heat island effect, and global circulation of pollutants.

UNIT-III

[10 hours]

Pollution in Metal Industries: Pollution in Iron and Steel industries and Non-ferrous Metals (Cu, Al, Zn, and Pb) industries and its control, Pollution Control in Ferrous & Non-ferrous Foundries.

UNIT-IV

[10 hours]

Air pollution and control due to toxic and non-toxic gases, fumes, dust etc. during combustion, heating and roasting processes and industrial production, control methods, cleaning of gaseous effluents, recovery of economic value from gases.
Noise pollution Sources, effects and control, Odor problem Causes and control.

Course Outcomes

1. To apply the knowledge in order to reduce or control the air pollution.
2. To apply the knowledge in order to reduce the pollution in metallurgical industries.

Text Books

1. C. S. Rao, "Environmental Pollution Control Engineering", New Age International Publishers, 2nd Edition, 2015, ISBN: 9788122418354.

Reference Books

1. G. E. Best, "Environmental Pollution Studies", Liverpool University Press, 1st Edition, 1999, ISBN: 9780853239239.
2. M. K. Hill, "Understanding Environmental Pollution", Cambridge University Press, 3rd Edition, 2010, ISBN: 9780521736695.
3. H. C. Perkins, "Air Pollution", McGraw Hill Higher Education, 1st Edition, 1947, ISBN: 9780070493025.
4. J. J. Peirce, P. A. Vesilind and R. Weiner, "Environmental Pollution and Control", Butterworth-Heinemann, 4th Edition, 1997, ISBN: 9780750698993.

Web Resources

1. NPTEL Course on "Environmental Air Pollution"
(http://nptel.ac.in/courses/105102089/

DEPARTMENT OF MATERIALS AND METALLUGICAL ENGINEERING
INDUS INSTITUTE OF TECHNOLOGY AND ENGINEERING
INDUS UNIVERSITY

Subject: **Additive Manufacturing (EL-1)**								
Program: **B.Tech. (Metallurgical Engineering)**				Subject Code: **MME0510**				Semester: **V**
Teaching Scheme (Hours per week)				**Examination Evaluation Scheme (Marks)**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	0	0	3	16/40	0	24/60	0	100

Course Objectives

1. To introduce the basic concepts of additive manufacturing, define various classifications, and assess their advantages and limitations.
2. Able to select various materials suitable for additive manufacturing and know their properties, and applications.
3. To understand the working principles of various additive manufacturing processes.

CONTENTS

UNIT-I

[10 hours]

Introduction to Additive Manufacturing: fundamental concepts, classification of additive manufacturing processes, additive manufacturing process chain, evolution of additive manufacturing processes, advantages and limitations of additive manufacturing.

UNIT-II

[10 hours]

Selection of raw materials used for additive manufacturing, microstructure and properties of metals used for advanced manufacturing, design for metal additive manufacturing, guidelines for metal additive manufacturing, guideline for part consolidation.

UNIT-III

[10 hours]

Additive Manufacturing Processes: photopolymerization, extrusion, sheet lamination, binder jetting, material jetting, directed energy deposition, and powder-bed fusion processes; solid-state additive manufacturing, WAAM and hybrid (additive + subtractive) processes; additive manufacturing equipment, post-processing of additive manufactured parts; additive manufacturing of common engineering metals; comparison of various additive manufacturing technologies, selection of processes for additive manufacturing.

UNIT-IV

[12 hours]

Qualification for metal additive manufacturing, properties and applications of products prepared via additive manufacturing, process-structure-property relationship in additively manufactured products, Printability of metals and alloys.
Market, cost, present challenges, and future of additive manufacturing, computational tools for design analysis, and optimisation of additive manufacturing parts.

Course Outcomes

1. To know about various applications of additive manufacturing.
2. To evaluate the influence of eachtechnological parameter on various types of additive manufacturing process.
3. To optimize material and technological parameters of additive manufacturing process.

Reference Books

1. I. Gibson, D.W. Rosen, B. Stucker, Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, Springer, 2010 (ISBN: 9781441911193).
2. Bhaskar Dutta, Sudarshan S. Babu, Bradley H. Jared, Science, Technology, and Applications of Metals in Additive Manufacturing, Elsevier, 2019 (ISBN: 9780128166345).
3. O. Diegel, A. Nordin, D. Motte, A Practical Guide to Design for Additive Manufacturing, Springer International Publishing, Springer Nature Singapore Pte Ltd., 2020.
4. B. Almangour (ed.), Additive Manufacturing of Emerging Materials, Springer International Publishing, 2019.

Web Resources

1. NPTEL Course on “Theory and Practice of Non Destructive Testing”
(https://nptel.ac.in/courses/113/106/113106070/)
2. NPTEL Course on “Materials Characterization”
(https://nptel.ac.in/courses/113/106/113106034/

Subject: **Energy Economy and Waste Management (OE–6)**								
Program: **B. Tech in Metallurgical Engineering**				Subject Code: **MME0508**			Semester: **V**	
Teaching Scheme (Hours per week)				**Examination Evaluation Scheme (Marks)**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	0	0	3	16/40	0	24/60	0	100

Course Objectives

1. To understand economic and ability to apply economic and financial evaluation of energy projects.
2. To learn the basics of cost calculation for electricity and heat production from CHP and power plants.

CONTENTS

UNIT-I

[10 hours]

Introduction Energy basics; Energy defined, Alternative classifications of Energy, India and world energy consumption and trade. Energy and multidimensional interactions, Introduction to energy system, Energy balance, Analysis of energy balance information, Energy demand, Management of Energy Demand, Economy of energy supply, Carbon credit.

UNIT-II

[10 hours]

Fossil Fuel Markets Coal, oil, natural gas.
Economics of Non-Renewable resource supply.
Financing Energy Development Energy resources and economic rent (economic rent, leasing and taxation of energy resources, government revenues), Allocation of resources over time and financing energy development (discounting, "levelized" costs of renewable resources, Cost Benefit Analysis, Laffer Curve, Interrelationship between energy system and LCOE, depletion of non-renewable resources), GDP, GNP, Energy futures.

UNIT-III

[10 hours]

Solid Waste Management & Disposal
Introduction to solid waste management, the disposal decades, the nature of the problem, Methods of waste disposal (Treatment/disposal Technologies): dumping, sanitary landfills mechanical-biological treatment, incineration, anaerobic digestion, composting; recycling of plastics, batteries.

UNIT-IV

[10 hours]

Liquid Waste Management Introduction to liquid waste management, types and sources of liquid waste, Management of liquid waste: Human waste management, sullage management, Industrial waste management, Collection, storage, and treatment of liquid waste: septic tanks, anaerobic biogas reactor, and Centralized wastewater treatment systems.

Course Outcomes

1. To design processes for the treatment of waste water and the sludges that arise from them.
2. To discuss the operational aspects of handling hazardous wastes.
3. To describe methods for the recycling and minimization of solid wastes.

Text Books

1. S. C. Bhattacharyya, "Energy Economics: Concepts, Issues, Markets and Governance", Springer, 1st Edition, 2011, ISBN: 9780857292674.
2. F. E. Banks, "Energy Economics: A Modern Introduction", Springer, 1st Edition, 2000, ISBN: 9781461370543.
3. R. Rhyner, L. J. Schwartz, R. B. Wenger and M. G. Kohrell, "Waste Management and Resource Recovery", CRC Press, 1st Edition, 1995, ISBN: 9780873715720.

Reference Books

1. E. Enger, B. Smith, "Environmental Science", McGraw-Hill Education, 14th Edition, 2015, ISBN: 9780073532554.
2. H. S. Muralidhara, "Solid/Liquid Separation: Waste Management and Productivity Enhancement", Battelle Pr, 1st Edition, 1990, ISBN: 9780935470543.
3. L. C. Hunt, J. Evans, "International Handbook on the Economics of Energy", Edward Elgar Publishing Ltd, Reprint Edition, 2011, ISBN: 9780857938251.
4. R. J. Eden, "Energy Economics: Growth, Resources, and Policies", Cambridge University Press, 1st Edition, 1983, ISBN: 9780521281607.

Web Resources

1. The Mises Academy Online Course on "Adventures in Energy Economics" (https://www.youtube.com/watch?v=Ie8VxbIM1Kc)

6TH SEMESTER

Subject: **Metal Forming**								
Program: **B. Tech in Metallurgical Engineering**				Subject Code: **MME0601**			Semester: **VI**	
Teaching Scheme (Hours per week)				**Examination Evaluation Scheme (Marks)**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	1	0	4	16/40	0	24/60	0	100

Course Objectives

1. To provide knowledge about the basic concepts of deformations and energy requirements.
2. To understand different methods of deformations to produce various shapes.
3. To teach them various strengthening mechanism of metals.

CONTENTS

UNIT-I

[10 hours]

Fundamentals of metal working: Yield criteria, Von-Mises equation, Classification of metal forming processes, Mechanics of metal working, Flow curve for materials, Temperature in Metal Working, Hot working, Cold working & Warm working, Strain rate effect of metallurgical structure and non-metallic inclusion on the manufacturing process, Workability, Residual stresses, Annealing of cold-worked metals.

UNIT-II

[10 hours]

Forging: Classification of forgoing processes, Forging equipment and operations, Open die forging, Closed die forging, Plane strain forging analysis, Forging defects, Metallurgical variables associated with forging, Powder metallurgy forging, Residual stresses in forging.

Rolling: Terminology of rolled products, Different kinds of rolling mills, Deformation zone in rolling, Neutral point, Angle of bite, Forward slip, Roll flattening, Rolling variables, Hot rolling, Cold rolling, Rolling of blooms billets, slabs, plates, strips, sheets, bars, rods & light section, Lay out of different mills for rolling of above products, Elementary roll pass design, Forces and geometrical relationships in rolling, Defects in rolled products. Galvanizing of cold rolled products.

UNIT-III

[10 hours]

Extrusion: Classification of extrusion processes, Direct and indirect extrusion, Impact extrusion, Hydrostatic extrusion, Extrusion equipment, Extrusion ratio, Process variables, Lubrication &defects in extrusion, Derivation of extrusion pressure, Extrusion of tubing, Production of seamless pipe and tubing.

Drawing: Rods, wires and tubes: Theory and practice of wire drawing, Wire drawing equipment, Variables in wire drawing, Defects in formed products.

UNIT-IV

[10 hours]

Sheet metal working: Shearing, Blanking, Bending, Stretch forming, Deep drawing, Spinning, Piercing, Swaging, Embossing, Coining, High energy rate forming, explosive forming, electromagnetic forming, electro hydraulic forming, formability diagrams, Super-plasticity.

Advancement of metal forming processes: Advanced and newer trend of incremental forming.

Course Outcomes

1. To solve different numerical pertaining to different metal forming techniques.
2. To apply the concepts of forming processes and discern the effect of variables on the productivity.
3. To solve practical example on the testing.

Text Books

1. G. E. Dieter, "Mechanical Metallurgy", McGraw-Hill, 3rd Edition, 2013, ISBN: 9781259064791.

Reference Books

1. P. N. Rao, "Manufacturing Technology (Foundry, Forming and Welding)", Tata McGraw Hill Education Private Limited, 4th Edition, 2013, ISBN: 9789383286614.
2. W. F. Hosford and R. M. Caddell, "Metal Forming: Mechanics and Metallurgy", Cambridge University Press, 4th Edition, 2014, ISBN: 9781107670969.
3. K. Lange, "Deformation Handbook of Metal Forming", Society of Manufacturing Engineers, New Edition, 1985, ISBN: 9780872634572.

Web Resources

1. NPTEL MOOC Course on "Forming" (http://nptel.ac.in/courses/112106153/)
2. EdX Online Course on "Mechanical Behavior of Materials" (https://courses.edx.org/courses/MITx/3.032x/3T2014/info)
3. NPTEL MOOC Course on "Fundamentals of Material Processing - I" (https://onlinecourses.nptel.ac.in/noc17_mm09/preview)
4. NPTEL MOOC Course on "Fundamentals of Material Processing - I" (https://onlinecourses.nptel.ac.in/noc16_mm11/preview)

5. EdX Online Course on “Fundamentals of Manufacturing Processes” (https://www.edx.org/course/fundamentals-manufacturing-processes-mitx-2-008x)
6. NPTEL MOOC Course on “Manufacturing Process Technology I & II” (https://onlinecourses.nptel.ac.in/noc17_me03/preview)

Subject: **Powder Metallurgy**								
Program: **B. Tech in Metallurgical Engineering**				Subject Code: **MME00608**			Semester: **VI**	
Teaching Scheme (Hours per week)				**Examination Evaluation Scheme (Marks)**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	0	0	3	16/40	0	24/60	0	100

Course Objectives

1. To define and explain basic conditions of successful application of powder metallurgy technology for production of materials and components.
2. To formulate advantages and disadvantages of powder metallurgy.
3. To classify typical representatives of individual powder metallurgy technologies.

CONTENTS

UNIT-I

[10 hours]

Introduction: Historical and modern developments in P/M. Advantages limitations and applications of Powder Metallurgy.

Characteristics of metal powder in terms of particle size, shape and size distribution, Characteristics of powder mass such as apparent density, tap density, flow rate, friction conditions. Properties of green compacts and sintered compacts.

UNIT-II

[10 hours]

Important methods of metal powder manufacturing like machining, milling, atomization, electrodeposition, reduction from oxide, carbonyl process, production of alloy powders, new development.

Powder conditioning, fundamentals of powder compaction, density distribution in green compacts, types of compaction presses, compaction tooling and role of lubricants. Single and double die compaction, isostatic pressing, hot pressing, effect of variables on sintering, sintering atmospheres and sintering furnaces.

UNIT-III

[10 hours]

Powder rolling, powder forging, powder extrusion and explosive forming technique Definition of sintering, stages of sintering

UNIT-IV

[10 hours]

Mechanism of sintering, liquid-phase sintering, infiltration process. Study of sintered bearings, cutting tools, and metallic filters. Study of friction and antifriction parts and electrical contact materials.

Course Outcomes

1. To evaluate and propose optimum technology for preparation of powder materials.
2. To evaluate and evaluate influence of individual technological parameters on basic powder metallurgy operations.
3. To optimize material and technological parameters of production.

Text Books

1. A. K. Sinha, "Powder Metallurgy", Dhanpat Rai Publications, 2nd Edition, 2006, ISBN: 9788189928513.
2. W. D. Jones, "Fundamental Principles of Powder Metallurgy", E. Arnold, 1st Edition, 1960, ASIN: B0007IXN18.

Reference Books

1. H. H. Hausner, "Handbook of Powder Metallurgy", Chemical Publishing Co. Inc., 1st Edition, 1973, ISBN: 9780820602196.
2. G. S. Upadhyaya, "Powder Metallurgy Technology", Cambridge International Science Publishing, 1stEdition, 1998, ISBN: 9781898326403.

Web Resources

1. NPTEL MOOC Course on "Fundamentals of Material Processing - I" (https://onlinecourses.nptel.ac.in/noc17_mm09/preview)
2. NPTEL MOOC Course on "Fundamentals of Material Processing - I" (https://onlinecourses.nptel.ac.in/noc16_mm11/preview)
3. EdX Online Course on "Fundamentals of Manufacturing Processes" (https://www.edx.org/course/fundamentals-manufacturing-processes-mitx-2-008x)

DEPARTMENT OF MATERIALS AND METALLUGICAL ENGINEERING
INDUS INSTITUTE OF TECHNOLOGY AND ENGINEERING
INDUS UNIVERSITY

Subject: **Electrometallurgy and Corrosion**								
Program: **B. Tech in Metallurgical Engineering**				Subject Code: **MME0603**			Semester: **VI**	
Teaching Scheme (Hours per week)				**Examination Evaluation Scheme (Marks)**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	0	2	4	16/40	16/40	24/60	24/60	200

Course Objectives

1. To be knowledgeable of the influence of a material's composition and microstructure on its corrosion performance.
2. To be knowledgeable of the effect of an electrolyte's composition on the corrosion of metals.
3. To be able to identify materials that will exhibit adequate corrosion resistance in a particular environment.
4. To be able to propose economically viable remedial actions that will eliminate or reduce corrosion to a tolerable level.

CONTENTS

UNIT-I

[10 hours]

Basics of Electrochemistry

Faradays' laws of electrolysis, current efficiency, current density, electrode potentials, Thermodynamics and Kinetics of Electrode Processes- Polarization Curves, Concept of Over-Potential, Kinetics of Passivity and Transpassivity, Nernst's Equation, EMF Series, Evan's Corrosion Diagram, Galvanic Series. Pourbiax Diagram for Metal Water System, Applications and Limitations.

UNIT-II

[10 hours]

Forms of Corrosion

The relevance of corrosion studies, forms of corrosion, Uniform Corrosion, Galvanic Corrosion, Crevice Corrosion, Pitting Corrosion, Intergranular Corrosion, Selective Leaching, Erosion Corrosion, stress cracking corrosion, Hydrogen Damage.

High Temperature Corrosion

High Temperature Corrosion in Different Atmosphere, Effect of Doping, Alloying Elements, Coating Methods for High Temperature Corrosion Protection, Pilling Bedworth Ratio and its applications.

UNIT-III

[10 hours]

Corrosion Protection

Principles of Protection, Selection of Suitable Design, Inhibition, Coating Methods, Anodic protection and Cathodic protection.

Electro deposition

Classification and mechanism of electrodeposition processes. Electroplating of copper, Nickel and Chromium. Principles of Alloy plating and electroless plating, Anodising, Galvanizing.

UNIT-IV

[10 hours]

Factors affecting Corrosion

Environment affecting corrosion, effects of soil, chemicals, moisture and atmospheric Gases,temperature and velocity, metallurgical factors.

Corrosion Testing

Physical and Electrochemical Methods such as ASTM standard methods A262 Practice A to E and their equivalents, Surface Preparation, Exposure Technique, Corrosion Rate Measurements.

Material Selection to Combat Corrosion

Specific Corrosion Applications Such as Marine Industry, Petrochemical Industry, High Temperature Service, Chemical Industry, Automobile, High Temperature & High Pressure corrosion in Industries.

Electrometallurgy and Corrosion Lab (List of Experiments)

Exp.No.	Title
1	To prepare the samples for corrosion testing.
2	To determine corrosion rate of given sample by weight loss method in H_2SO_4 Solution.
3	To determine corrosion rate of given sample by weight loss method in NaCl solution.
4	To determine corrosion rate of sample by weight loss method in HCl solution.
5	Comparative study of corrosion rate by weightless method for different acid solutions.
6	To study and perform IGC corrosion of stainless steel.
7	Determination of Inter granular corrosion susceptibility by microstructure evaluation.
8	To study and observe galvanic corrosion of two metals.

9	Observation of effect of anodic area and type of material on galvanic corrosion of metals.
10	To perform & observe pitting corrosion in stainless steel.
11	To study & perform the effect of current density on anodic dissolution.
12	To perform the electroplating of copper on a given base metal.
13	To perform the Anodizing of Aluminum in H_2SO_4 Solution.
14	To study and perform cathodic protection of a metal by sacrificial anode method.
15	To Study corrosion rate by Tafel Extrapolation method.

Course Outcomes

1. To understand the origin of the difference in electrical potential across an interface, in particular, metal/electrolyte interface.
2. To understand the relationship between rates of electrochemical reactions and the potential drop across interfaces.
3. To understand the causes of and the mechanisms of various types of corrosion, including uniform corrosion, galvanic corrosion, crevice corrosion, pitting corrosion, intergranular corrosion, and various modes of environmentally assisted cracking.

Text Books

1. M. G. Fontana and N. D. Greene, "Corrosion Engineering", McGraw Hill Higher Education, 2nd Edition, 1978, ISBN: 9780070214613.

Reference Books

1. D. A. Jones, "Principles and Prevention of Corrosion", Pearson, 2nd Edition, 1995, ISBN: 9780133599930.
2. H. H. Uhlig and R. W. Revie, "Corrosion and Corrosion Control", Wiley-Interscience, 4thEdition, 2008, ISBN: 9780471732792.
3. L. L. Shreir, "Corrosion: Volume 1", Newnes-Butterworth, 2nd Edition, 1976, ISBN: 9780408001090.
4. G. T. Burstein, L. L. Shreir and R. A. Jarman, "Corrosion: Volume 2", Butterworth-Heinemann, 3rdEdition, 1994, ISBN: 9780750610773.
5. M. Pourbaix, "Atlas of Electrochemical Equilibria in Aqueous Solutions", NACE International, 1st Edition, 1974, ISBN: 0915567989.
6. J. O. M. Bockris and A. K. N. Reddy, Modern Electrochemistry: Volume I", Springer, 2nd Edition, 1998, ISBN: 9780306455544.
7. J. O. M. Bockris and A. K. N. Reddy, Modern Electrochemistry: Volume II", Springer, 1970 Edition, 1973, ISBN: 9780306250026.

Web Resources

1. NPTEL Online Course on "Advances in Corrosion Engineering" (http://nptel.ac.in/courses/113108051/)

DEPARTMENT OF MATERIALS AND METALLUGICAL ENGINEERING
INDUS INSTITUTE OF TECHNOLOGY AND ENGINEERING
INDUS UNIVERSITY

Subject: **Metal Joining Processes**								
Program: **B. Tech in Metallurgical Engineering**				Subject Code: **MME0604**			Semester: **VI**	
Teaching Scheme (Hours per week)				**Examination Evaluation Scheme (Marks)**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	0	2	4	16/40	16/40	24/60	24/60	200

Course Objectives

1. To understand the basics & importance of joining processes.
2. To understand the various types of joining operations used in the industries.
3. To correlate the basic machine products with the of product applicability & use skills for specific joining processes.

CONTENTS

UNIT-I

[10 hours]

History, Importance of metal joining processes, Classification of metal joining processes - Classification based on application of filler material & without filler material, source of energy, fusion and pressure welding processes, joint design and edge preparation, physics of arc, characteristic of arc. Welding positions. Welding Symbols, Soldering and brazing: Difference between both the processes, consumables used, methods of brazing, fluxes used, and their purpose and flux residue treatment, comparison with welding process.

UNIT-II

[10 hours]

Metal transfer, forces acting on the arc, different modes of metal transfer, heat flow in metals, prediction of heating and cooling rates. Manual metal arc(MMA) or shielded metal arc (SMA) welding, Submerged arc welding (SAW), Gas metal arc welding (GMAW) or MIG/MAG welding, TIG welding, Plasma Arc welding: Principle, Equipment requirement, electrodes for welding of structural steels, electrode coating classification, process description, shielding gases, advantages and disadvantages, application of processes.

UNIT-III

[10 hours]

Resistance welding, general principle of heat generation in resistance welding, application of resistance welding processes. Process details and working principle of spot, seam, and projection welding, electrode materials, shapes of electrodes, electrode cooling, selection of welding currents, voltages. Gas welding, electron beam welding, and laser beam welding.

UNIT-IV

[10 hours]

Other welding processes: Friction welding, friction stir welding, explosive welding, ultrasonic welding, diffusion welding, electroslag and electro gas welding etc. Weldability and defects: introduction, weldability test, weldability of ferrous and non-ferrous materials, joining metallurgy of the dissimilar metals, cladding and hard facing metals, welding for additive manufacturing etc., welding defects. Inspection and testing methods.

Metal Joining Processes Lab (List of Experiments)

Experiment No.	Title
1	To study the edge preparation and preparation of different types of weld joints
2	To study effect of proportion of oxygen and acetylene on the gas welding flame
3	To study the effect of welding parameters on weld quality by SMAW welding
4	Characterization of weldments prepared by SMAW
5	Preparation of joints using Tungsten Inert Gas welding
6	Characterization of weldments prepared by TIG
7	Preparation of joints using Metal Inert Gas welding
8	Characterization of weldments prepared by MIG
9	Preparation of different type of joints uses spot welding and butt welding
10	Characterization of weldments prepared by spot and butt welding
11	To study the effect of rpm on weld microstructure by friction welding
12	Characterization of weldments prepared by friction welding
13	To study the effect of gas flow rate on weld quality by MIG welding
14	Application of welding Gauge
15	Effect of GTAW parameters on weld bead morphology

Course Outcomes

1. To develop the capability to analyze and select the various criteria of quality joining of the

metals.
2. To implement effectively and accurately the suitable joining process to improve the efficiency & life of the product / Machines.
3. To learn various quality dimensions of joints, cost factor, factor of safety etc.
4. To understand the advance processes of joining& its applicability.

Text Books

1. J.F. Lancaster, "The Metallurgy of Welding, Brazing and Soldering", George Allen and Unwin, 2nd Edition, 1970, ASIN: B000OA77G6.

2. D.R. Milner and R.L. Apps, "Introduction to Welding and Brazing", Elsevier, 1st Edition, 1968, ISBN: 9780080123066.

Reference Books

1. P.N. Rao, "Manufacturing Technology (Foundry, Forming and Welding)", Mcgraw Hill Higher Education, 3rd Edition, 2008, ISBN: 9780070087989

2. J. F. Lancaster, "The Physics of Welding", Pergamon Press, 2nd Edition, 1986, ISBN: 9780080340760.

3. R. S. Parmar, "Welding Processing and Technology", Khanna Publishers, 2nd Edition, 2003, ISBN: 9788174091260.

4. O.P. Khanna, "A Textbook of Welding Technology",Dhanpat Rai Publications, 2013 Edition, 2013, ISBN: 9788189928360.

5. ASM International, "ASM Handbook - Vol. 6", ASM International, 10th Edition, 1993, ISBN: 9780871703828.

Web Resources

1. NPTEL MOOC Course on "Joining Technologies for Metals"

(https://onlinecourses.nptel.ac.in/noc17_me09/preview)

Subject: **Composite Materials (EL–2)**								
Program: **B. Tech in Metallurgical Engineering**				Subject Code: **MME0605**			Semester: **VI**	
Teaching Scheme (Hours per week)				**Examination Evaluation Scheme (Marks)**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	0	0	3	16/40	0	24/60	0	100

Course Objectives

1. To name the three main divisions of composite materials, and cite the distinguishing feature of each.
2. To cite the difference in strengthening mechanism for large-particle and dispersion-strengthened particle-reinforced composites.
3. To distinguish the three different types of fiber reinforced composites on the basis of fiber length and orientation; comment on the distinctive mechanical characteristics for each type.

CONTENTS

UNIT-I

[10 hours]

Introduction, Review of current developments, Importance of Composites over other materials. Advantages and disadvantages of composite materials, Matrix and reinforcement phases, Classification of composite materials, Types of composite materials – dispersion strengthened composites, particulate composites, concretes, Fiber-reinforced Composites, Structural composite.

UNIT-II

[10 hours]

Types of reinforcements – Whiskers and fibers, preparation, structure and properties of different reinforcing fibers, carbon fibers, glass fibers, polymer fibers and alumina fibers. Fiber-reinforced Composites: Influence of Fiber Length, Critical Fiber Length, Short and Continuous Fibers, Influence of Fiber Orientation and Concentration, Fiber reinforced composites with different matrix systems, polymer matrix (thermoset and thermoplastic) composites, metal matrix composites and ceramic matrix composites, carbon-carbon composite, intermetallic composites.

UNIT-III

[10 hours]

Strengthening mechanisms, Aspect Ratio, Rule of Mixture, Role of interfaces in composites, Toughening mechanisms in PMCs, MMCs, and CMCs, Wettability and bonding. Properties of

composites: Mechanical Properties of composite, Effect of fiber volume content, orientation of fibers & void contents on mechanical properties of composite, fracture behaviour of composites, Applications of composites in different field, Environmental effects in composites.

UNIT-IV

[10 hours]

Fabrication of composites, Fiber Forms, Prepregs, Moulding Compounds-Processes, Lay-Ups, Filament Winding, Pultrusion, vacuum bag moulding, Pressure bag moulding, vacuum impregnation and injection moulding, transfer moulding, Green composites; Synthesis and Properties of Nanocomposites, Hybrid composites.

Course Outcomes

1. To calculate longitudinal modulus and longitudinal strength for an aligned and continuous fiber reinforced composite.
2. To compute longitudinal strengths for discontinuous and aligned fibrous composite materials.
3. To note the three common fiber reinforcements used in polymer-matrix composites, and, for each, cite both desirable characteristics and limitations.
4. To cite the desirable features of metal-matrix composites.

Text Books

1. K.K. Chawla, "Composite Materials – Science & Engineering", Springer, 2nd Edition, 1988, ISBN: 9788181284907.
2. M. M. Schwartz, "Composite Materials: Volume 1: Properties, Non-destructive Testing and Repair", Prentice Hall, 1st Edition, 1996, ISBN: 9780133000474.
3. L.J. Broutman and R.M. Krock, "Modern Composite Materials", Addison-Wesley, 1st Edition, 1967, ISBN: 9780201006292.
4. D. A. Colling and T. Vasilos, "Industrial Materials: Polymers, Ceramics and Composites", Prentice Hall, 1st Edition, 1656, ASIN: B01FJ2EVOY.

Reference Books

1. D. R. Askeland and P. Phule, "The Science and Engineering of Materials", Thomson, 5thEdition, 2005, ISBN: 9780534553968.
2. G. Lubin, "Hand Book of Composites", Springer, 2nd Edition, 1982, ISBN: 9780442248970.
3. D. Hull, "An Introduction to Composites Materials", Cambridge University Press, 2nd Edition, 1996, ISBN: 9780521388559.

Web Resources

1. NPTEL MOOC Course on "Processing of Polymers and Polymer Composites" (https://onlinecourses.nptel.ac.in/noc17_me36/preview)

DEPARTMENT OF MATERIALS AND METALLUGICAL ENGINEERING
INDUS INSTITUTE OF TECHNOLOGY AND ENGINEERING
INDUS UNIVERSITY

Subject: **Modelling of Metallurgical Processes (EL–2)**								
Program: **B. Tech in Metallurgical Engineering**				Subject Code: **MT0609**				Semester: **VI**
Teaching Scheme (Hours per week)				**Examination Evaluation Scheme (Marks)**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	0	0	3	16/40	0	24/60	0	100

Course Objectives

1. To understand metallurgical and materials processes and some simulation applications.
2. To understand fundamental principles, methods, and approaches of simulation and modeling.
3. To develop the theoretical background of metallurgical processes' simulation and modeling.

CONTENTS

UNIT-I

[10 hours]

Introduction to modelling & simulation, Basic principles of modelling & simulation, Mathematical and physical basis of modeling & its methodology, Basic approaches and techniques of modelling & simulation, Examples of metallurgical and materials processes.

UNIT-II

[10 hours]

Mass and energy balances, and simultaneous solutions, In-class demonstration of modelling software, Modelling and Simulation in Materials Science, Application of the methodology for materials behavior and processing problems, Modeling of structural materials, Description of certain metallurgical processes (roasting, smelting, leaching, precipitation, electrolysis, refining, etc.) and steps of their mathematical modelling and approaches.

UNIT-III

[10 hours]

Concepts of batch, and continuous processes in metallurgy, Determining the effect of controlling parameters, such as composition, temperature, particle size, concentration, pressure, gas/liquid/solid flow rate, stirring speed, current density, etc., and mathematical modelling thereof. Assigning these parameters to the student groups as term projects.

UNIT-IV

[10 hours]

Case studies on mathematical modelling from iron and steel making will be discussed such as modelling of blast furnace, basic oxygen furnace, electric arc furnace, ladle furnace, ingot casting, continuous casting, forging, electroslag refining, sheet metal forming etc. some case studies on physical modelling such as ladle furnace, tundish, continous casting etc.

Course Outcomes

1. To understand the importance and necessity of simulation and modelling studies in metallurgical and materials processes.
2. To improve his/her theoretical background on simulation and modelling of metallurgical and materials processes.
3. To be aware of the resulting innovations by applying simulation and modelling software.
4. To create a model of a given metallurgical process by considering the related control parameters.

Text Books

1. R. I. L. Guthrie, "Engineering Process Metallurgy", Oxford University Press, Revised Edition, 1993, ISBN: 9780198563679.
2. Z.H.Barber, "Introduction of Materials Modeling", Maney Publishing, 1st Edition, 2005, ISBN: 9781902653761.
3. R. P. King, C. L. Schneider and E. A. King, "Modeling and Simulation of Mineral Processing Systems", Society for Mining, Metallurgy, and Exploration, 2nd Edition, 2012, ISBN:9780873353458.

Reference Books

1. K. Popovich and P. J. Masterman, "Real-Time Simulation Technologies: Principles, Methodologies, and Applications", CRC Press, 1st Edition, 2012, ISBN: 9781439846650.
2. N.Ghasem, "Computer Methods in Chemical Engineering", CRC Press, 1st Edition, 2011, 2012, ISBN: 9781439849996.
4. Bautista G.R., Wesely J.R., Warren W.G., 1986, "Hydrometallurgical Reactor Design and Kinetics", TMS, 1st Edition, 1987, ISBN: 9780873390552.
5. Suhas V. Patankar, "Numerical Heat Transfer and Fluid Flow".

Web Resources

1. MIT OpenCourseWare Course on "Atomistic Computer Modeling of Materials" (https://ocw.mit.edu/courses/materials-science-and-engineering/3-320-atomistic-computer-modeling-of-materials-sma-5107-spring-2005/index.htm)
2. MIT OpenCourseWare Course on "Introduction to Modeling and Simulation" (https://ocw.mit.edu/courses/materials-science-and-engineering/3-021j-introduction-to-modeling-and-simulation-spring-2012/index.htm)

Subject: **Nano Technology (EL–2)**								
Program: **B. Tech in Metallurgical Engineering**				Subject Code: **MME0607**			Semester: **VI**	
Teaching Scheme (Hours per week)				**Examination Evaluation Scheme (Marks)**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	0	0	3	16/40	0	24/60	0	100

Course Objectives

1. To describe and explain Nanotechnology.
2. To describe Nanomaterials based on their dimensionality.
3. To explain the importance of reduction in materials dimensionality, and its relationship with materials properties.

CONTENTS

UNIT-I

[10 hours]

Introduction to Nanomaterials and nanotechnology, historical developments. An overview of scope & applications of nanotechnology, classifications and types of Nanomaterials. Basic understanding of various phenomena at nanoscale namely size confinement, interfacial surface phenomena.

UNIT-II

[10 hours]

Introduction to basic building blocks namely atoms, molecules, self-assembly, carbon nanotubes, nanocrystals, fullerenes, quantum dots, and quantum wires. Functional properties of nanomaterials such as physical, mechanical, electrical, magnetic, chemical and optical properties. Size dependence of material at nano scale. Bulk vs. nano properties of materials.

UNIT-III

[10 hours]

Synthesis & fabrication techniques 'Top down' vs. 'Bottom-up' approach of synthesis.
Review of synthesis methods namely sol-gel method, chemical vapour deposition, physical vapour deposition, sputtering, milling etc. Consolidation methods for nano powders such as coldisostatic pressing (CIP), hot isostatic pressing (HIP), Dynamic compaction, Conventional and Micro wave sintering.

UNIT-IV

[10 hours]

Characterization of nano materials by using transmission electron microscopy (TEM, atomic force microscopy (AFM) and Dynamic Light Scattering (DLS) measurement techniques. Applications of nano materials namely nano grained structural materials & nano composites, nano magnetic materials, chemical applications etc.

Course Outcomes

1. To explain top-down approaches for Nano material fabrication, and give some examples.
2. To perform a literature survey on a chosen topic in the scientific literature.
3. To write a scientific report with appropriate references and citations.

Text Books

1. A.K.Bandopadhyay, "Nano Materials", New Age International Publishers, 1st Edition, 2009, ISBN: 9781906574277.
2. K. K. Chattopadhyay and A. N. Banerjee "Introduction to Nanoscience and Nanotechnology", PHI Learning, 1st Edition, 2009, ISBN: 9788120336087
3. C.C. Koch, "Nanostructured Materials: Professing, Properties and Applications", William Andrew Publishing, 2nd Edition, 2006, ISBN: 9780815518426.

Reference Books

1. G. Timp, "Nanotechnology", Springer, 1999th Edition, 1999, ISBN: 9780387983349.
2. J.H. Fendler, "Nanoparticles and Nanostructured Films: Preparation, Characterization and Applications", Wiley-VCH, 1st Edition, 1998, ISBN: 9783527294435.
3. Z.L. Wang, Z. Zhang and Y. Lim, "Handbook of Nanophase and Nanostructured Materials", Springer, 1st Edition, 2002, ISBN: 9780306472497.
4. H.S. Nalwa, "Handbook of Nanostructured Materials and Nanotechnology", Academic Press, 5 Volume Set Edition, 1999, ISBN: 9780471958932.
5. M. Meyyappan, "Carbon Nanotubes: Science and Applications", CRC Press, 1st Edition, 2004, ISBN:9780203494936.
6. L. L. Shaw, C. Suryanarayana and Rajiv S. Mishra, "Processing and Properties of Structural Nanomaterials", Wiley-TMS, 1st Edition, 2003, ISBN: 9780873395588.
7. A. S. Edelstein and R.C. Cammarata, "Nanomaterials: Synthesis, Properties & Applications", Taylor and Francis, 1st Edition, 1996, ISBN: 9780750303583.

Web Resources

1. NPTEL MOOC Course on "Soft Nano Technology"
(https://onlinecourses.nptel.ac.in/noc16_ch06/preview)
2. EdX Online Course on "Nanotechnology: Fundamentals of Nanotransistors"
(https://www.edx.org/course/nanotechnology-fundamentals-purduex-nano530x)

DEPARTMENT OF MATERIALS AND METALLUGICAL ENGINEERING
INDUS INSTITUTE OF TECHNOLOGY AND ENGINEERING
INDUS UNIVERSITY

Subject: **Phase Transformations (EL–3)**								
Program: **B. Tech in Metallurgical Engineering**				Subject Code: **MME0602**			Semester: **VI**	
Teaching Scheme (Hours per week)				**Examination Evaluation Scheme (Marks)**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	0	0	3	16/40	0	24/60	0	100

Course Objectives

1. To provide the student with an understanding of the basic principles and mechanisms underlying both solid-solid and liquid-solid phase transformations with an emphasis on metallic materials.
2. To apply the concepts of thermodynamics, diffusion and kinetics, and crystallography (crystal structure and symmetry in materials) to develop a clear understanding of the free energy changes and kinetics associated with various types of phase transformations.

CONTENTS

UNIT-I

[10 hours]

Review of Thermodynamics:

Equilibrium, Single Component Systems, Binary Solutions, Equilibrium in Heterogeneous Systems, Binary Phase Diagrams, Kinetics of Phase Transformations.

Review of Diffusion:

Atomics Mechanisms of Diffusion, Interstitial diffusion, Self-Diffusion, Vacancy Diffusion, Diffusion in Substitutional Alloys.

UNIT-II

[10 hours]

Solidification:

Nucleation in pure metals, Growth of a pure Solid, Alloy Solidification, Solidification during Quenching from Melt.

UNIT-III

[10 hours]

Diffusional Transformations in Solids:

Nucleation in solids - Homogeneous and Heterogeneous, Overall Transformation Kinetics – TTT Diagrams, Precipitation in Age Hardening Alloys, Cellular Precipitation, Eutectoid Decomposition, Massive Transformations, Ordering Transformations.

UNIT-IV

[10 hours]

Diffusionless Transformations:

Characteristics of Martensitic Transformations, Martensite Crystallography, Martensite Nucleation, Martensite Growth, Tempering of Ferrous Martensite, Strain induced transformation.

Course Outcomes

1. To apply and couple the basic concepts of thermodynamics, diffusion, and crystallography.
2. To apply the concepts of phase transformations in order to design new materials/alloy systems for advancement of technologies.

Text Books

1. D. A. Porter, K. E. Easterling and M. Sherif "Phase Transformations in Metals and Alloys", CRC Press, 3rd Edition, 2009, ISBN: 9781420062106.

Reference Books

1. P.G. Shewmon, "Transformations in Metals", Indo American Books, 1st Edition, 2007, ISBN: 9788189617189.
2. M. Hillert, "Phase Equilibria, Phase Diagrams and Phase Transformations: Their Thermodynamic Basis", Cambridge University Press, 2nd Edition, 2007, ISBN: 9780521853514.
3. V. Raghavan, "Solid State Phase Transformations", Prentice Hall India Learning Private Limited, 1st Edition, 1987, ISBN: 9788120304604.

Web Resources

1. SWAYAMMOOC Course on "Phase Transformation in Materials" (https://swayam.gov.in/course/3796-phase-transformation-in-materials)

DEPARTMENT OF MATERIALS AND METALLUGICAL ENGINEERING
INDUS INSTITUTE OF TECHNOLOGY AND ENGINEERING
INDUS UNIVERSITY

Subject: **Industrial Ceramics and Polymers (EL–3)**								
Program: **B. Tech in Metallurgical Engineering**				Subject Code: **MME0606**			Semester: **VI**	
Teaching Scheme (Hours per week)				**Examination Evaluation Scheme (Marks)**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	0	0	3	16/40	0	24/60	0	100

Course Objectives

1. To understand the various types of ceramic and different between advance and traditional ceramics.
2. To understand the developing methods of raw materials.
3. To understand the sintering mechanism of ceramics and characteristics of sintered ceramics.
4. To get the knowledge of processing method of ceramics.

CONTENTS

UNIT-I

[10 hours]

Introduction, definition and scope of ceramics. Historical perspective, classification, Structure of ceramics, Pauling's Rules, Ceramic Phase Diagrams, Silicate structures.

Traditional ceramics:

An overview, history, raw materials, Shaping, sintering, abrasives, White wares, Glazing and decoration.

Refractories:

Types of refractories, fireclay, mullite, silica refractories, magnesite refractories, carbide & nitride refractories, pure oxide refractories, chrome refractories

UNIT-II

[10 hours]

Glass:

Nature of glass, structure, glass forming systems, silicate systems, non-silicate systems, Types of Glasses, manufacture of glass, Viscous Deformation of Glasses, Ceramic Glass, Advance ceramics and their application.

Processing of Ceramics:

Processing of ceramic powders, shape forming operations- Dry pressing, isostatic pressing, Hot Pressing, HIP, slip casting, Extrusion method, injection molding, hot pressing and hot isostatic

pressing, Sol –gel processing and monolithic ceramics. Thermal Treatment- Drying & Firing of ceramics: kiln design & sintering mechanism and densification,

Properties:

(Thermal, Mechanical & Optical properties) of sintered ceramics. Ceramics used for energy and environment technologies (fuel cell, lithium battery, gas sensor and catalytic csupport), ceramic coating, ceramic in bio-medical application, nanotechnology and ceramics

UNIT-III

[10 hours]

Historical Background, Basic concepts of polymeric materials, Classification and forms of Polymers, Tacticity, Functionality, Different types of polymerization, chemistry of

Polymerization:

Chain polymerization, Step polymerization, Polymerization Techniques: Bulk polymerization, Solution polymerization, Suspension polymerization, and Emulsion polymerization.

UNIT-IV

[10 hours]

Molecular weight & Size, Determination of molecular weight - methods for measuring number average, weight average, viscosity average MW, Molecular weight distribution, Degree of Polymerization, Polymer Degradation, Glass transition temperature, Crystallinity, Elastomers, Fiber and plastic, Additives, Processing of polymers- Extrusion, Injection Molding, Transfer Moulding, and Blow Molding.

Course Outcomes

1. To understand the process that is used to produce glass–ceramics.
2. To apply the idea about properties, applications of different clay products, refractory ceramics and abrasive ceramics.
3. To compare between traditional and advance ceramics for application of advance ceramics.
4. To understand the polymer molecule in terms of its chain structure and, in addition, how the molecule may be generated from repeat units.
5. To understand the number–average and weight–average molecular weights, and degree of polymerization.

Text Books

1. A. K. Galwey, “Chemistry of Solids”, Chapman & Hall Publication, 1st Edition, 1967, ISBN: 9780412086601.
2. T. Pollack, “Properties of Matter”, McGraw Hill publication, 3rd Edition, 1993, ASIN: B0006QP5LM.
3. M. W. Barsoum, “Fundamentals of Ceramics”, CRC Press, 1st Edition, 2002, ISBN: 9780750309028.

4. W.D. Kingery, "Introduction to Ceramics", Wiley-Blackwell Publications, 2nd Edition, 1976, ISBN: 9780471478607.
5. J. S. Reed, "Introduction to the Principles of Ceramic Processing", Wiley-Blackwell Publications, 2nd Edition, 1995, ISBN: 9780471597216.
6. A. Paul, "Chemistry of Glasses", Springer publications, 2nd Edition, 1989, ISBN: 9780412278204.

Reference Books

1. D. R. Askeland,"The Science and Engineering of Materials", Wadsworth Publishing Co Inc, 6thEdition, 2010, ISBN: 9780495296027.
2. W. F Smith, "Materials Science & Engineering", McGraw-Hill Education; 5th Edition, 2009, ISBN: 9780073529240.
3. F.H.Norton, "Elements of Ceramics",Addison-Wesley Press, 1st Edition, 1952, ISBN: 9781114163560.
4. S. K. H. Choudhary, "Materials Science and Processes", Indian Book Distributing Co, 1st Edition, 1985, ISBN: 9780906216002.

Web Resources

1. NPTEL MOOC Course on "Processing of Polymers and Polymer Composites" (https://onlinecourses.nptel.ac.in/noc17_me36/preview)

DEPARTMENT OF MATERIALS AND METALLUGICAL ENGINEERING
INDUS INSTITUTE OF TECHNOLOGY AND ENGINEERING
INDUS UNIVERSITY

Subject: **Advanced Materials and Applications (EL–3)**								
Program: **B. Tech in Metallurgical Engineering**				Subject Code: **MME0610**			Semester: **VI**	
Teaching Scheme (Hours per week)				**Examination Evaluation Scheme (Marks)**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	0	0	3	16/40	0	24/60	0	100

Course Objectives

1. To impart the knowledge on special steels, alloy cast iron, light metals and some super alloys.
2. To know about various techniques for manufacturing of advanced materials.

CONTENTS

UNIT-I

[10 hours]

Special steels Ferritic, Austenitic, Martensitic, Duplex and Precipitation hardenable stainless steels, Dual phase steels, High speed steels, Hadfield steels, Free cutting steels, Tool Steels, manganese steels, chrome steels, electrical steels, bearing steels, spring steels, heat resistant steels, HSLA steels, Alloy cast iron.

UNIT-II

[10 hours]

Light metals and their alloys Aluminum, magnesium and titanium alloys, Metallurgical aspects, Mechanical Properties and applications.

Super alloys, Classifications, Properties and their application.

Rapid Solidification Techniques, Atomic arrangement, Comparison with crystalline alloys, properties & applications.

UNIT-III

[10 hours]

Nanomaterials & technology Definition, Types of nanomaterials including carbon nanotubes, Methods for creating nano structures, Physical and mechanical properties and their applications.

Smart materials Shape memory alloys, piezoelectric materials.

UNIT-IV

[10 hours]

Biomaterials Property requirement, Ni-Ti alloy, Co-Cr-Mo alloys Miscellaneous Advanced Materials Magnetic materials, Engineering polymers, ceramics and composites, aerospace materials, cryogenic materials, semi conducting and superconducting materials.

Course Outcomes

1. To apply the knowledge of various types of advanced materials to develop new technologies and applications.
2. To innovate the existing ideas and ways of making advanced materials in order to reduce the cost of manufacturing and increasing the applications.

Text Books

1. D. R. Askeland and P. P. Phule, "The Science and Engineering of Materials", Wadsworth Publishin, 6th Edition, 2010, ISBN: 9780495296027.

Reference Books

1. R. K. Dogra and A. K. Sharma, "Advances in Material Science", S. K. Kataria and Sons, 1st Edition, 2013, ISBN:9788188458318.
2. L. H. V. Vlack, "Elements of Materials science", Pearson Publication, 6thEdition, 2008, ISBN: 9780201093148.
3. R. A. Flinn and P. K. Trojan, "Engineering Materials and Applications", Jaico Publishing House, 1st Edition, 1999, ISBN: 9788172246778.
4. I. J. Polmear, "Light Alloys: Metallurgy of Light Metals", Halsted Publications, 3rd Edition, 1982, ISBN: 9780470235652.
5. G. Timp, "Nano Technology", Springer, 1st Edition, 1999, ISBN: 9780387983349.

Web Resources

1. NPTEL Online Course on "Advanced Materials and Processes" (http://nptel.ac.in/courses/113105057/)

DEPARTMENT OF MATERIALS AND METALLUGICAL ENGINEERING
INDUS INSTITUTE OF TECHNOLOGY AND ENGINEERING
INDUS UNIVERSITY

Subject: **Introduction to Nanomaterials (OE–7)**								
Program: **B. Tech in Metallurgical Engineering**				Subject Code: **MME0611**			Semester: **VI**	
Teaching Scheme (Hours per week)				**Examination Evaluation Scheme (Marks)**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	0	0	3	16/40	0	24/60	0	100

Course Objectives

1. To describe and explain Nanotechnology.
2. To describe Nanomaterials based on their dimensionality.
3. To explain the importance of reduction in materials dimensionality, and its relationship with materials properties.

CONTENTS

UNIT-I

[10 hours]

Introduction to Nanomaterials and nanotechnology, historical developments. An overview of scope & applications of nanotechnology, classifications and types of Nanomaterials. Basic understanding of various phenomena at nanoscale namely size confinement, interfacial surface phenomena.

UNIT-II

[10 hours]

Introduction to basic building blocks namely atoms, molecules, self-assembly, carbon nanotubes, nanocrystals, fullerenes, quantum dots, and quantum wires.

UNIT-III

[10 hours]

Synthesis & fabrication techniques 'Top down' vs. 'Bottom-up' approach of synthesis.
Review of synthesis methods namely sol-gel method, chemical vapour deposition, physical vapour deposition, sputtering, milling etc. Compaction and sintering.

UNIT-IV

[10 hours]

Characterization of nanomaterials by using transmission electron microscopy (TEM, atomic force microscopy (AFM).

Course Outcomes

1. To explain top-down approaches for Nano material fabrication, and give some examples.
2. To perform a literature survey on a chosen topic in the scientific literature.
3. To write a scientific report with appropriate references and citations.

Text Books

1. A.K.Bandopadhyay, "Nano Materials", New Age International Publishers, 1st Edition, 2009, ISBN: 9781906574277.
2. K. K. Chattopadhyay and A. N. Banerjee "Introduction to Nanoscience and Nanotechnology", PHI Learning, 1st Edition, 2009, ISBN: 9788120336087
3. C.C. Koch, "Nanostructured Materials: Professing, Properties and Applications", William Andrew Publishing, 2nd Edition, 2006, ISBN: 9780815518426.

Reference Books

1. G. Timp, "Nanotechnology", Springer, 1999th Edition, 1999, ISBN: 9780387983349.
2. J.H. Fendler, "Nanoparticles and Nanostructured Films: Preparation, Characterization and Applications", Wiley-VCH, 1st Edition, 1998, ISBN: 9783527294435.
3. Z.L. Wang, Z. Zhang and Y. Lim, "Handbook of Nanophase and Nanostructured Materials", Springer, 1st Edition, 2002, ISBN: 9780306472497.
4. H.S. Nalwa, "Handbook of Nanostructured Materials and Nanotechnology", Academic Press, 5 Volume Set Edition, 1999, ISBN: 9780471958932.
5. M. Meyyappan, "Carbon Nanotubes: Science and Applications", CRC Press, 1st Edition, 2004, ISBN:9780203494936.
6. L. L. Shaw, C. Suryanarayana and Rajiv S. Mishra, "Processing and Properties of Structural Nanomaterials", Wiley-TMS, 1st Edition, 2003, ISBN: 9780873395588.
7. A. S. Edelstein and R.C. Cammarata, "Nanomaterials: Synthesis, Properties & Applications", Taylor and Francis, 1st Edition, 1996, ISBN: 9780750303583.

Web Resources

1. NPTEL MOOC Course on "Soft Nano Technology"
(https://onlinecourses.nptel.ac.in/noc16_ch06/preview)
2. EdX Online Course on "Nanotechnology: Fundamentals of Nanotransistors"
(https://www.edx.org/course/nanotechnology-fundamentals-purduex-nano530x)

7TH SEMESTER

DEPARTMENT OF MATERIALS AND METALLUGICAL ENGINEERING
INDUS INSTITUTE OF TECHNOLOGY AND ENGINEERING
INDUS UNIVERSITY

Subject: **Material Testing and Characterization**								
Program: **B. Tech in Metallurgical Engineering**				Subject Code: **MME0701**			Semester: **VII**	
Teaching Scheme (Hours per week)				**Examination Evaluation Scheme (Marks)**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	0	2	4	16/40	16/40	24/60	24/60	200

Course Objectives

1. To understand different types of Mechanical testing (i.e. destructive testing and non-destructive testing).
2. To understand different types of standards related to different mechanical testing.
3. To understand standard procedure for mechanical testing.
4. To provide knowledge about the basic concepts of behind material characterization.
5. To understand different methods of characterization in order to understand different properties.

CONTENTS

UNIT-I

[10 hours]

Introduction:

Importance of Material Testing. Classification of various types of testing methods – destructive and non-destructive testing. Selection of testing methods. Importance of calibration of testing instruments. Calibration methods and standards for various tests.

Tensile and Hardness test:

Engineering and true stress –strain curve, principle of stress and strain measurement, bend test measurement of ductility and formability, compression test, yield stress and proof stress, universal tensile testing machine and tensometer, Numericals of Tensile test.

Brinell, Vickers and Rockwell hardness tests, Meyer hardness test, Analysis of indentation by an indenter, Relationship between hardness and the flow curve, Micro-hardness tests.

UNIT-II

[10 hours]

Impact and Torsion test:

Types of impact tests and their relative merits and demerits. Ductile-brittle transitions behavior and its significance.

Mechanical properties in torsion, Torsional stresses for large plastic strains, Types of torsion failures, Torsion test vs. tension test, Hot torsion test.

Fatigue and Creep Testing:

Elementary treatment of fatigue phenomenon, S – N curve and corrosion fatigue, fatigue testing principle, Signification of Creep testing procedure, creep curve and its interpretation, stress-rupture test. Metallurgical and mechanical factors affecting, creep and fatigue failures.

UNIT-III

[10 hours]

Importance of Material characterization, Classification of techniques for characterization. Image formation, resolving power, numerical aperture, empty magnification, depth of focus, components of microscopes, important lens defects and their correction, principles of phase contrast, interference and polarized light microscopy, Image analyzer.
Thermal Analysis techniques: Basic Principles, Working and applications of DTA, TGA, TMA and DSC.

UNIT-IV

[10 hours]

Studies by electron microscopes: Principle, Construction and Working of TEM, SEM, STEM with their merits, demerit and applications, techniques of replica preparation.
X-Ray diffraction and their applications: Working principles of diffractometer. Indexing of XRD patterns, determination of crystal structure, lattice parameter, and crystallite size by diffraction techniques. Numerical based on XRD.
Spectroscopic and Chemical analysis Techniques: IR & Raman spectroscopy, Energy Dispersive Spectroscopy (EDS) & Wavelength Dispersive Spectroscopy (WDS), XRF.

Material Testing and Standards Lab (List of Experiments)

Experiment No.	Title
1	To study the Brinell hardness testing machine & perform the Brinell hardness test.
2	To study the Rockwell hardness testing machine & perform the Rockwell hardness test.
3	To study the Vickers hardness testing machine & perform the Vickers hardness test.
4	To determine the impact toughness of a given specimen by Izod test and Charpy test.
5	To determine the tensile strength of specimen.
6	To study room temperature creep strength of specimen.
7	To study room temperature fatigue strength of specimen.

8	To perform compression & bending tests on UTM.
9	Visual Inspection of fractured surfaces.
10	To perform Dye Penetration Test for given sample.
11	To study of Magnetic particle tester.
12	To study Ultrasonic Flaw Detector
13	To study Eddy Current Tester.
14	Detailed study of Radiographic Testing Method.
15	To study In situ Metallographic using replica technique

Course Outcomes

1. To develop the capability to analyze and select the various testing techniques for materials.
2. To understand various standards available to perform specific tests on different materials.
3. To solve different numerical pertaining to optical microscopy and X-ray diffraction.
4. To understand the basic elements of electron microscopy.
5. To understand the basic aspects of optical characterization methods including Raman and infrared spectroscopy.

Text Books

1. G. E. Dieter, "Mechanical Metallurgy", McGraw Hill, 3rd Edition, 2013, ISBN: 9781259064791.
2. A.V.K. Suryanarayana, "Testing of Metallic Materials", B. S.Publications, 2nd Edition, 2007, ISBN: 9788178001340.
3. J. M. Walls, "Methods of Surface Analysis: Techniques & Applications", Cambridge University Press, 1stEdition, 1989, ISBN: 9780521305648.
4. J. P. Sibilia, "A Guide to Materials Characterization and Chemical Analysis", Wiley-Blackwell, 2nd Edition, 1996, ISBN: 9780471186335.
5. P. R. Khangaonkar, "An Introduction to Materials Characterization", Penram International Publishing, 1st Edition, 2010, ISBN: 9788187972808.

Reference Books

1. R. Abbaschian, L. Abbaschian and R.E. Reed-Hill, "Physical Metallurgy Principles", Wadsworth Publishing Co Inc, 4th Edition, 2008, ISBN: 9780495082545.
2. R. W. Hertzberg, R. P. Vinci and J. L. Hertzberg, "Deformation and Fracture Mechanics of Engineering Materials", John Wiley & Sons, 5th Edition, 2012, ISBN: 9780470527801.
3. T. H. Courtney, "Mechanical Behavior of Materials", McGraw-Hill Education, 2nd Edition, 2017,ISBN: 9781259027512.
4. M. Spencer, "Fundamentals of Light Microscopy",Cambridge University Press, 1stEdition, 1982, ISBN: 9780521289672.
5. D. B. Williams and C. B. Carter, "Transmission Electron Microscopy: A Textbook for aterials Science",Springer, 2ndEdition, 2009, ISBN: 9780387765020.

6. C. R. Brundle, C. A. Evans Jr. and S. Wilson, “Encyclopedia of Materials Characterization”, Butterworth-Heinemann, Braille Edition, 1992, ISBN: 9780750691680.
7. B. D. Cullity and S. R. Stock, "Elements of X-Ray Diffraction", Pearson, 3rd Edition, 2001, ISBN: 9780201610918.

Web Resources

1. NPTEL MOOC Course on “Theory and Practice of Non Destructive Testing” (https://onlinecourses.nptel.ac.in/noc16_mm07/preview)
2. NPTEL MOOC Course on “Fundamentals of Optical and Scanning Electron Microscopy” (https://swayam.gov.in/course/1399-fundamentals-of-optical-and-scanning-electron-microscopy)
3. NPTEL MOOC Course on “X-ray Crystallography & Diffraction” (https://onlinecourses.nptel.ac.in/noc17_mm11/preview)
4. NPTEL MOOC Course on “Fundamentals of X-ray Diffraction & Transmission Electron Microscopy” (https://onlinecourses.nptel.ac.in/noc16_mm06/preview)
5. NPTEL MOOC Course on “Electron Diffraction and Imaging” (https://onlinecourses.nptel.ac.in/noc17_me30/preview)

DEPARTMENT OF MATERIALS AND METALLUGICAL ENGINEERING
INDUS INSTITUTE OF TECHNOLOGY AND ENGINEERING
INDUS UNIVERSITY

Subject: **Alloy Design (EL–4)**								
Program: **B. Tech in Metallurgical Engineering**				Subject Code: **MME0702**			Semester: **VII**	
Teaching Scheme (Hours per week)				**Examination Evaluation Scheme (Marks)**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	0	0	3	16/40	0	24/60	0	100

Course Objectives

1. To provide knowledge about the basic concept of alloys and its properties.
2. To impart the importance of overall design in metallurgy.
3. To help them understand all newer types of alloys and its applications.

CONTENTS

UNIT-I

[10 hours]

Concept & Effect on properties

Concept of alloy design, Steps in alloy design, Significance of alloy design Single phase, dual phase and multiphase materials, Effect of matrix on properties of materials, Effect of size, shape and distribution of second phase on mechanical properties of alloys.

UNIT-II

[10 hours]

Strengthening Mechanisms

Precipitation and particle coarsening, recrystallization and grain growth. Solid/Liquid phase transformation in pure metals, single phase alloys, constitutional super cooling and eutectic alloys.

UNIT-III

[10 hours]

Alloy Design for better mechanical properties

Alloy design for better tensile strength, ductility, toughness, fatigue strength, creep strength, wear resistance and elevated temperature.

UNIT-IV

[10 hours]

Types of Alloy Steels & its applications

Types of Stainless Steels – Its Introduction, properties and applications High strength low alloy steels, Maraging steels, High speed steels, Hadfield steel and Super alloys. Alloy design of

lightweight and high Strength powder metallurgical Al based alloys Application of computer-based methods for alloy designing.

Course Outcomes

1. To make them understand strengthening mechanisms used in alloying.
2. To study alloy design for particular mechanical properties & its overall importance.
3. To apply the knowledge to develop new materials that can be useful in new technologies and development.

Text Books

1. H.E. Boyer, "Selection of Materials for component Design: Source Book", ASM International, 1st Edition, 1986, ISBN: 9780871702562.
2. M. F. Ashby, "Materials Selection in Mechanical Design", Butterworth-Heinemann; 4th Edition, 2010, ISBN: 9781856176637.
3. S. Ranganathan, V.S.Arunachalam and R.W. Cahn, "Alloy Design", Indian Academy of Science, 1st Edition, 1981, OCLC: 10804290.
4. J. K.Tien and G. S. Ansell, "Alloy and Microstructural Design", Academic Press, 1st Edition, 1977, ISBN: 9780126908503.

Reference Books

1. ASM International, "ASM Handbook - Vol.1",ASM International, 10th Edition, 1990, ISBN: 9780871703774.
2. R. M. Brick, A. W. Pense and R. B. Gordon, "Structure & Properties of Alloys", Mcgraw-Hill College, 4th Edition, 1977, ISBN: 9780070077218.
3. B. P. Bardes, "Metals Hand Book - Vol. 1", ASM International, 9th Edition, 1978, ISBN: 9780871700070.
4. ASM International, "ASM Handbook - Vol. 2", ASM International, 10th Edition, 1990, ISBN: 9780871703781.

Web Resources

1. NPTEL Online Course on "Materials Selection and Design"
(http://nptel.ac.in/courses/112104122)

DEPARTMENT OF MATERIALS AND METALLUGICAL ENGINEERING
INDUS INSTITUTE OF TECHNOLOGY AND ENGINEERING
INDUS UNIVERSITY

Subject: **Surface Engineering (EL–4)**								
Program: **B. Tech in Metallurgical Engineering**				Subject Code: **MME0703**			Semester: **VII**	
Teaching Scheme (Hours per week)				**Examination Evaluation Scheme (Marks)**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	0	0	3	16/40	0	24/60	0	100

Course Objectives

1. To understand the concept and basis of surface engineering.
2. To understand the various methods of surface modification techniques.
3. To understand the phenomena behind the modification techniques.

CONTENTS

UNIT-I

[10 hours]

Scope of surface engineering in metals, ceramics, polymers and composites, Surface Preparation methods such as Chemical, Electrochemical, Mechanical- Sand Blasting, Shot peening, Shot blasting, Hydroblasting, Vapor Phase Degreasing etc., Properties of Various Coating, Coating Methods.

UNIT-II

[10 hours]

Chromating, Phosphating, Anodizing, Thermochemical processes, industrial practice, economy and energy considerations. Electrolytic and Electroless plating of important metals and alloys

UNIT-III

[10 hours]

Surface pretreatments, Hot Dipping, galvanizing, testing/evaluation of surface properties.

Coating from Vapour Phase

PVD, CVD, Various Methods used, mechanisms, important reactions involved and applications.

UNIT-IV

[10 hours]

Sputtering, Plasma Spray & Ion Implantation Methods, mechanisms & applications. Surface modification by directed energy beams like ion, electron and laser beams, novelty of composition and microstructures.

Diffusion Coating: Various Techniques For Single And Multiple Element Coating, High Temperature Coating- Carburising, Carbonitriding, Silicanizing, Chromizing, Aluminizing, Boronizing, Boronitriding.

Course Outcomes

1. To co-relate various techniques with desired properties and applications.
2. To understand various advanced machineries and their working principles like plasma, laser, and ion beam, etc.

Text Books

1. J. R. Davis, "Surface Engineering for Corrosion and Wear Resistance", CRC Press, 1st Edition, 2001, ISBN: 9780871707000.
2. RJ. Rudzki, "Surface Finishing Systems: Metal and Non-metal", ASM International, 1st Edition, 1984, ISBN: 9780904477078.
3. J. A. Murphy, "Surface Preparation and Finishes for Metal", McGraw-Hill, 1st Edition, 1971, ISBN: 9780070595576.
4. ASM International, "ASM Handbook Volume 5: Surface Engineering", ASM International, 10th Edition, 1994, ISBN: 9780871703842.

Reference Books

1. P. G. Sheasby and R. Pinner, "The Surface Treatment and Finishing of Aluminum and Its Alloys", ASM International, 6th Edition, 2001, ISBN: 904477215.
2. R. S. Mishra and M. W. Mahoney, "Friction Stir Welding and Processing", ASM International, 1st Edition, 2007, ISBN: 9780871708489.

Web Resources

1. EdX Online Course on "Surface Science: Methods of Surface Analysis" (https://www.edx.org/course/surface-science-methods-surface-analysis-mephix-mephi006x)

DEPARTMENT OF MATERIALS AND METALLUGICAL ENGINEERING
INDUS INSTITUTE OF TECHNOLOGY AND ENGINEERING
INDUS UNIVERSITY

Subject: **Nuclear Metallurgy (EL–4)**								
Program: **B. Tech in Metallurgical Engineering**				Subject Code: **MME0704**			Semester: **VII**	
Teaching Scheme (Hours per week)				**Examination Evaluation Scheme (Marks)**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	0	0	3	16/40	0	24/60	0	100

Course Objectives

1. To understand the importance of nuclear energy and reactors towards the growth of Indian energy scenario.
2. To understand the requirements of materials for critical components of nuclear reactors.

CONTENTS

UNIT-I

[10 hours]

Atomic Structure, Fundamental Properties. Atomic Nucleus. Radio activity, half-life period and isotopes Fission, fusion and other nuclear reactions. Critical mass. Neutron cross section, Multiplication factor and nuclear disintegration.

UNIT-II

[10 hours]

Essential parts of Nuclear Reactor. Reactor types, Reactor Fuel Cycle. Indian atomic power plants, Nuclear power program me in India and future trends. Difference in separation methods as compared to conventional methods.

UNIT-III

[10 hours]

Purity requirement of nuclear metal. Separation process- Ion and Solvent extraction techniques. Occurrence, extraction mechanical and physical properties and uses of Uranium and Thorium. Occurrence, extraction mechanical and physical properties and uses of Zirconium, hafnium and plutonium.

UNIT-IV

[10 hours]

Methods of enrichment and production of ultrahigh purity metals and their importance in nuclear metallurgy. Influence of neutron damage on mechanical properties. Effects of radiation damage

on steel and Zircalloys, Scope of beryllium in nuclear plants. Extraction, occurrence, physical and mechanical properties of Be and its applications, Reactor pressure vessel embrittlement (indicating parameters, mechanisms, mitigation methods).

Course Outcomes

1. To apply the knowledge of extraction of nuclear fuels.
2. To predict the mechanisms for failures in the materials used in nuclear reactors.

Text Books

1. A. R. Kaufmann,"Nuclear Reactor Fuel Elements – Metallurgy & Fabrication", John Wiley and Sons, 1st Edition, 1962, ISBN: 9780470460689.

Reference Books

1. H.S.Ray, R. Shridhar and K. P. Abraham, "Extraction of Non-Ferrous Metals",Affiliated East-West Press Pvt Ltd, 1st Edition, 2006, ISBN: 9788185095639.
2. D. G. Cacuci, "Handbook of Nuclear Engineering: Vol. 1: Nuclear Engineering Fundamentals", Springer, 2010 Edition, 2010, ISBN: 9780387981307.

Web Resources

1. EdX Online Course on "Nuclear Reactor Physics Basics"
(https://www.edx.org/course/nuclear-reactor-physics-basics-mephix-mephi005x)
2. EdX Online Course on "Understanding Nuclear Energy"
(https://www.edx.org/course/understanding-nuclear-energy-delftx-nuclear01x-0)

DEPARTMENT OF MATERIALS AND METALLUGICAL ENGINEERING
INDUS INSTITUTE OF TECHNOLOGY AND ENGINEERING
INDUS UNIVERSITY

Subject: **Advanced Ferrous Metallurgy (EL–5)**								
Program: **B. Tech in Metallurgical Engineering**				Subject Code: **MME0705**			Semester: **VII**	
Teaching Scheme (Hours per week)				**Examination Evaluation Scheme (Marks)**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	0	0	3	16/40	0	24/60	0	100

Course Objectives

1. To impart the overall idea of how Steel is produced the history of Steel making.
2. To know about various techniques of raw material preparation for charging in iron making furnace, construction and operation of iron making furnace and reactions occurring in the furnace, reaction mechanism inside the blast furnace and post treatment to make steel.

CONTENTS

UNIT-I

[10 hours]

Thermodynamics of oxides and their reduction:
Thermodynamics and kinetics of iron oxide reduction. Kinetics of solid- solid and solid-gas reactions.

UNIT-II

[10 hours]

General Problems related to Indian Steel plants: Problems of Indian Steel Plants. High temperature properties of iron bearing materials.

UNIT-III

[10 hours]

Pre-treatment Techniques:
Pre-treatment of hot metal. Physico-chemical aspects of pre-treatment processes. Status of hot metal treatment in India.

Electric Arc Furnace (EAF) steel making:
Design of EAF-AC, DC electric arc. Latest trends in EAF design and operation.

Induction furnace steel making:

Secondary steel making processes:
Alloy steel making in EAF using secondary refining. Continuous casting.

UNIT-IV

[10 hours]

Roll of synthetic slags. Electro-slag refining. Slag-metal reaction in iron and steel making. Ferro-alloy production. Application of plasma technology.

Course Outcomes

1. To apply the knowledge of various types of routes of iron making to practical scenarios.
2. To innovate the existing ideas and ways of making Iron and developing the technology to make this process energy intensive and cost effective.

Text Books

1. A. Ghosh, "Principles of Secondary Processing and Casting of Liquid Steel", South Asia Books, 1st Edition, 1990, ISBN: 9788120405585.
2. F.P.Edneral, "Electrometallurgy of Steel and Ferro-alloys, Vol. I & II", Mir Publishers, 1st Edition, 1979, ISBN: 9780828515184.

Reference Books

1. A. W. Cramb, "Making, Shaping and Treating of Steels", Association of Iron and Steel Engineers, 11thEdition, 1985, ISBN: 9780930767020.
2. J. G. Peacey and W. G. Davenport, "Blast Furnace: Theory and Practice", Pergamon Press, Oxford, 1stEdition, 1979, ISBN: 9780080232584.

Web Resources

1. NPTEL MOOC Course on "Steel Quality: Role of Secondary Refining & Continuous Casting" (https://onlinecourses.nptel.ac.in/noc17_mm10/preview)
2. NPTEL Course on "Materials and Heat Balance in Metallurgical Processes" (http://nptel.ac.in/courses/113104060/26)

DEPARTMENT OF MATERIALS AND METALLUGICAL ENGINEERING
INDUS INSTITUTE OF TECHNOLOGY AND ENGINEERING
INDUS UNIVERSITY

Subject: **Selection of Materials and Failure Analysis (EL–5)**								
Program: **B. Tech in Metallurgical Engineering**				Subject Code: **MME0706**			Semester: **VII**	
Teaching Scheme (Hours per week)				**Examination Evaluation Scheme (Marks)**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	0	0	3	16/40	0	24/60	0	100

Course Objectives

1. To impart broad knowledge of Metallurgical aspects of engineering materials selection & technology practices to support design, application, installation, manufacturing, operation and maintenance for successful careers in Academics/ Research & industry that meet the needs of Society and multinational companies.
2. To understand various failure mechanisms for engineering materials.

CONTENTS

UNIT-I

[10 hours]

Philosophy of material selection, motivation for selection, relationship to available resources, concept of resource base, Criteria for selection of engineering materials – service requirements, ease of manufacturing, availability of materials and cost effectiveness. Selection for mechanical properties like strength, toughness, stiffness, fatigue, creep and temperature resistance.

UNIT-II

[10 hours]

Selection for surface durability like corrosion resistance, wear resistance. Relationship between material selection and material processing.

Identification of required properties. Selection of materials based on available property data and optimization to select the best material.

Case studies in material selection like materials for bearings, gears, automobile structures, aircraft components, ship structures, etc.

UNIT-III

[10 hours]

Importance of failure analysis and its relationship to material selection, fundamental causes of failure, general practice in failure analysis.

Failure- types and characteristics: Identification and characterization of ductile and brittle type of failures. Fracture mechanism, fracture modes and micro fractographic features.

UNIT-IV

[10 hours]

Concept and Mechanism of Failure: Identification and characterization of fatigue failures, types of fatigue, corrosion fatigue and contact fatigue, etc. Corrosion and corrosion related failures such as hydrogen embrittlement, stress corrosion cracking and high temperature failures.
In-process failures: Case studies, Service failures: Case studies.

Course Outcomes

1. To develop basic scientific principles and engineering fundamentals necessary to formulate, analyze and solve engineering &technical problems & demonstrate the ability to synthesize data and technical concepts for application to product design & developments.
2. To analyze and apply their understanding in order to perform failure analysis of various engineering materials and components.

Text Books

1. Donald J. Wulpi, "Understanding How Components Fail".
2. F.A.A. Cranes and J.A. Charles, "Selection and Use of Engineering Materials", Butterworth-Heinemann, 3rd Edition, 1989, ISBN: 9780750615495.
3. M. F. Ashby and D. R.H. Jones, "Engineering Materials – Vol. 1", Butterworth-Heinemann, 4th Edition, 2011, ISBN: 9780080966656.
4. H.J. Sharp, "Engineering Materials-Selection and Value Analysis", Heywood Books-Elsevier, 1st Edition, 1966, ASIN: B0000CMZQ9.
5. V.J. Colangelo and F.A. Heiser, "Analysis of Metallurgical Failures", Wiley-Interscience, 2nd Edition, 1987, ISBN: 9780471891680.
6. C. R. Brooks and A. Chaudhary, "Failure Analysis of Engineering Materials", McGraw-Hill Education, 1st Edition, 2001, ISBN: 9780071357586.
7. A.K. Das, "Metallurgy of Failure Analysis", McGraw-Hill Professional, 1st Edition, 1997, ISBN: 9780070158047.
8. M. F. Ashby and D. R. H. Jones, "Engineering Materials – Vol. 1", Butterworth-Heinemann, 4th Edition, 2012, ISBN: 9780080966687

Reference Books

1. American Society of Metals, "Metals Handbook –Failure Analysis and Prevention", American Society of Metals, 8th Edition, 1975, ASIN: B0026SIT3E.
2. American Society of Metals, "Metals Handbook – Fractography and Atlas of Fractographs", American Society of Metals, 8th Edition, 1974, ASIN: B000I1VM9Y.
3. M. Kutz, "Handbook of Materials Selection", Wiley, 1st Edition, 2002, ISBN: 9780471359241.
4. G.T. Murray and M. Dekker, "Handbook of Materials Selection for Engineering Applications", CRC Press, 1st Edition, 1997, ISBN: 9780824799106.

Web Resources

1. NPTEL Online Course on "Materials Selection and Design"
(http://nptel.ac.in/courses/112104122)

DEPARTMENT OF MATERIALS AND METALLUGICAL ENGINEERING
INDUS INSTITUTE OF TECHNOLOGY AND ENGINEERING
INDUS UNIVERSITY

Subject: **Computational Materials Science (EL–5)**								
Program: **B. Tech in Metallurgical Engineering**				Subject Code: **MME0707**			Semester: **VII**	
Teaching Scheme (Hours per week)				**Examination Evaluation Scheme (Marks)**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	0	0	3	16/40	0	24/60	0	100

Course Objectives

1. To provide hands-on experience with popular computational materials science and engineering software through a series of projects.
2. To understand different methods of modelling and simulation in order to understand different properties, structural evolution and possible applications.

CONTENTS

UNIT-I

[10 hours]

Introduction to Computational Materials Science, multiple scales in crystalline materials, materials scales for modelling, Introduction to simple numerical methods for solving coupled differential equations and for studying correlations, applications.

UNIT-II

[10 hours]

Quantum Mechanical Modeling:

Introduction, Hartree-Fock and Density function theory (DFT), plane wave based DFT calculations, equilibrium properties and surfaces from DFT calculations, atomistic modeling of defects in materials, applications.

Monte Carlo Methods:

Introduction, Kinetic, Lattice, applications.

UNIT-III

[10 hours]

Classical Equilibrium Statistical Mechanics:

Phase space, Hamiltonian's equation, macroscopic translation and rotation, phase space coordinates, canonical transformations, applications.

Molecular Dynamics:

Introduction, brief MD algorithm, micro-canonical ensemble (NVE), velocity-verlet algorithm, canonical ensemble (NVT), applications.

UNIT-IV

[10 hours]

Multiscale methods:

Introduction to multiscale models, sequential multiscale models, concurrent multiscale models, Hierarchial methods, partitioned-domain methods, spanning time scales, Statistical mechanics of systems in metastable equilibrium, applications.

Introduction to phase diagram modeling using CALPHAD and Thermo-Calc, applications.

Course Outcomes

1. To model different projects in: electronic structure calculation, molecular simulation, phase diagram modeling, finite element modeling, and materials selection.
2. To familiarize students with a broad survey of software tools in computational materials science, scientific computing, and prioritize the physical principles underlying the software to confer an understanding of their applicability and limitations.

Text Books

1. E. B. Tadmor and R. E. Miller, "Methods of Surface Analysis: Techniques & Applications", Cambridge University Press, 1st Edition, 2011, ISBN: 9780521856980.

Reference Books

1. Z. X. Guo, "Multiscale Materials Modelling: Fundamental and Applications",CRC Press, 1st Edition, 2007, ISBN: 9780849391101.
2. D. Raabe, "Computational Materials Science", Wiley-VCH Verlag GmbH, 1stEdition, 2004, ISBN: 9783527295418.

Web Resources

1. MITOpenCourseWare Course on "Atomistic Computer Modeling of Materials" (https://ocw.mit.edu/courses/materials-science-and-engineering/3-320-atomistic-computer-modeling-of-materials-sma-5107-spring-2005/index.htm)
2. MIT OpenCourseWare Course on "Introduction to Modeling and Simulation" (https://ocw.mit.edu/courses/materials-science-and-engineering/3-021j-introduction-to-modeling-and-simulation-spring-2012/index.htm)

DEPARTMENT OF MATERIALS AND METALLUGICAL ENGINEERING
INDUS INSTITUTE OF TECHNOLOGY AND ENGINEERING
INDUS UNIVERSITY

Subject: **Non Destructive Testing (EL–6)**								
Program: **B. Tech in Metallurgical Engineering**				Subject Code: **MME0708**			Semester: **VII**	
Teaching Scheme (Hours per week)				**Examination Evaluation Scheme (Marks)**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	0	0	3	16/40	0	24/60	0	100

Course Objectives

1. To understand the significance of testing of metallic and non-metallic materials and components without destroying them.
2. To study the application of these methods in assessing reliability of components & plants.
3. To study the life time assessment of components.

CONTENTS

UNIT-I

[10 hours]

Fundamentals and introduction to non-destructive testing. Scope and limitationsof NDT

Visual examination methods. Different visual examination aids.

Leak and pressure testing of industrial components. Various methods of pressure and leak testing underlying principles of these testing systems.

UNIT-II

[10 hours]

Dye penetrant Methods, Basic Principles, Capillary Action, Wetting and Non-Wetting Characteristics, Different Types of Penetrants, Detailed Procedure and Recent Developments in DPT.

Magnetic Particle Testing methods, Basic Principles of MPT, magnetization methods demagnetization methods, MPT equipment & instruments, sensitivity calibration of MPT equipment.

Ultrasonic methods of NDT-Basic principles of wave propagation, types of waves, transducers and transducer materials, advantages and limitations of UT.

UNIT-III

[10 hours]

Pulse Echo and Through Transmission techniques of UT, Calibration methods, use of standard blocks, Thickness determination by ultrasonic method. Study of A, B and C scan presentations.

Radiographic testing of metallic components. X-ray and Gamma-Ray radiography. Their principles, methods of generation. Industrial radiography techniques. Types of films, screens and penetrameters. Interpretation of radiographs. Film Processing. Radiography Contrast.

UNIT-IV

[10 hours]

Eddy current testing: Basic principles and applications such as detection of defects and characterization, sorting of materials, determination of film/coating thickness, measurement of electrical conductivity and magnetic permeability of materials. Eddy current testing equipment and its block diagram, different types of test coils and their applications.

Acoustic Emission Technique. Conductivity & resistivity methods and their applications. Thermal methods of NDT.

Selection Criteria for various NDT techniques.

Course Outcomes

1. To understand the principle and application of visual testing methods.
2. To understand principle of liquid penetration testing technique.
3. To understand the principle of magnetic particle testing and its applications.

Text Books

1. B. Raj,T. Jayakumar and M. Thavasimuthu, "Practical Non-Destructive Testing",Norosa Publishing House, 3rd Edition, 2014, ISBN: 9788173197970.
2. W. J. McGonnagle, "Non Destructive Testing", Routledge, 1stEdition, 1971, ISBN: 9780677005003.

Reference Books

1. J. Krautkramer, "Ultrasonic Testing of Materials", Allen & Unwin, 2nd Edition, 1969, ISBN: 9780046200015.
2. J. Prasad and C. G. K. Nair, "Non-Destructive Test and Evaluation of Materials",McGraw Hill Education, 2nd Edition, 2011, ISBN: 9781259061615.
3. R. Halmshaw, "Non-Destructive Testing (Metallurgy and Materials Science)", Butterworth-Heinemann, 2nd Edition, 1991, ISBN: 9780340545218.
4. L. Filipczynski, Z. Pawłowski and J. Wehr, "Ultrasonic Methods of Testing Materials", Butterworth, 1st Edition, 1966, ASIN: B00MJ3OOIU.

Web Resources

1. NPTEL MOOC Course on "Theory and Practice of Non Destructive Testing" (https://onlinecourses.nptel.ac.in/noc16_mm07/preview)

DEPARTMENT OF MATERIALS AND METALLUGICAL ENGINEERING
INDUS INSTITUTE OF TECHNOLOGY AND ENGINEERING
INDUS UNIVERSITY

Subject: **Advanced Foundry Technology (EL–6)**								
Program: **B. Tech in Metallurgical Engineering**				Subject Code: **MME0709**			Semester: **VII**	
Teaching Scheme (Hours per week)				**Examination Evaluation Scheme (Marks)**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	0	0	3	16/40	0	24/60	0	100

Course Objectives

1. To have adequate knowledge and understanding of the newer materials which are in the state of development so also the newer processes that are more competitive, case of solidification software and ISO 9000 as measures of producing quality castings.
2. To have adequate knowledge and understanding of the mechanization of foundry plants for faster rate of production and specifications for major equipment.

CONTENTS

UNIT-I

[10 hours]

New materials, processes & software applications: new core & mould binders & additives, new lining & refractory materials, magnetic moulding process, full mould process, vacuum moulding process, ISO-9000 computer applications in metal casting, use of solidification software & simulation, energy conservation in foundry industries.

UNIT-II

[10 hours]

Foundry mechanization: mechanical equipment in a foundry, sand preparation & control, sand handling & conveying system, moulding machines, sand slingers, pneumatic rammers, simultaneous jolt & squeeze, high pressure moulding, typical specifications for major equipment in foundry

UNIT-III

[10 hours]

Plant site location: plant layout of small scale & medium scale & large scale foundry, plant engineering/maintenance/services: plant machinery & equipment, environmental pollution & its control in foundry, consideration on layout & material handling system, modernization & mechanization of a foundry.

UNIT-IV

[10 hours]

Casting defects analysis & salvaging of defective castings by using techniques such as welding, brazing, braze welding & soldering, burning on, patches & plugs, impregnations of castings, quality control in pattern & mould making, melting & heat treatment, fettling & cleaning, use of statistical methods in quality control of casting.

Course Outcomes

1. To have an understanding on the layout of foundry plants, maintenance of machinery, equipment and material handling system.
2. To have an understanding on the quality control measures at various sections in foundry including analysis of defects and salvage of defective castings.

Text Books

1. T. V. R. Rao, "Metal Casting: Principles and Practice", New-Age InternationalPublishers, 1st Edition, 1998, ISBN: 9788122408430.
2. O. P. Khanna, "Foundry Technology", Dhanpat Rai Publications, 17th Edition, 2011, ISBN: 9788189928346.
3. P. Bidulya, "Steel Foundry Practices", Moscow Mir publications, 2nd Edition, 1968, OLCL: 841189189.

Reference Books

1. R. Trivedi, J. A. Sekhar and J. Mozumdar, "Principles of Solidification and Materials Processing (Vol. 1 & Vol. 2)", Trans Tech Publication, 1st Edition, 1990, ISBN: 9780878495948.
2. R. C. Gupta, "Proceedings of the International Conference on Environmental Management in Metallurgical Industries", Allied Publishers Limited, 1st Edition, 2000, ISBN: 8177641042.

Web Resources

1. NPTEL MOOCCourse on "Principles of Casting Technology"
(https://onlinecourses.nptel.ac.in/noc17_me11/preview)

DEPARTMENT OF MATERIALS AND METALLUGICAL ENGINEERING
INDUS INSTITUTE OF TECHNOLOGY AND ENGINEERING
INDUS UNIVERSITY

Subject: **Industrial Welding Codes and Standards (EL–6)**								
Program: **B. Tech in Metallurgical Engineering**				Subject Code: **MME0710**			Semester: **VII**	
Teaching Scheme (Hours per week)				**Examination Evaluation Scheme (Marks)**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	0	0	3	16/40	0	24/60	0	100

Course Objectives

1. To describe different welding codes and materials specifications.
2. To understand the fundamental principles, methods, and approaches of welding processes.
3. To develop the theoretical background of welding processes' applicability and effectiveness.

CONTENTS

UNIT-I

[10 hours]

Fabrication In Piping Industry: Process and product standards for manufacturing of pipe – welding procedure and welder qualification, field welding and inspection. Structural Welding Codes: Design requirements, allowable stress values, workmanship and inspection.

UNIT-II

[10 hours]

Fabrication of Pressure Vessel: Design requirements, fabrication methods, joint categories, welding and inspection, post weld heat treatment and hydrotesting, (ASME Sec VIII-1 & 2).

UNIT-III

[10 hours]

Welding procedure: Welding procedure specification, procedure qualification records. Welder Qualification: Performance qualification, variables.

UNIT-IV

[10 hours]

Materials: Introduction to materials standard and testing of materials, consumables testing and qualification as per ASME / AWS requirements. Consumables: Types of consumables, Consumable testing and qualification as per ASME / AWS requirements.

Course Outcomes

1. To understand the importance and necessity of selection of appropriate consumable, welding processes, welding parameters and testing procedures.

2. To apply his/her theoretical background on applicability of a welding process, parameters and weld testing.
3. To be aware of the use of various welding codes and standards widely used in industries.

Text Books

1. R. S. Parmar, "Welding Engineering and Technology", Khanna Publishers, 1st Edition, 2004, ISBN: 9788174090287.

Reference Books

1. American Society for Mechanical Engineers, "Boiler and Pressure Vessel Code Section VIII – Division 1 and Division 2", American Society for Mechanical Engineers, 2017, ISBN: 9780791870969.
2. American Society for Mechanical Engineers,"Boiler and Pressure Vessel Code Section IX-Welding and Brazing Qualifications",American Society for Mechanical Engineers, 2017, ISBN: 9780791871003.
3. American Society for Mechanical Engineers,"Boiler and Pressure Vessel Code Section II Part C: Specifications for Welding Rods, Electrodes, and Filler Metals",American Society for Mechanical Engineers, 2017, ISBN: 9780791870792.
4. American Society for Mechanical Engineers,"Boiler and Pressure Vessel Code Section II Part A: Ferrous Material Specifications", American Society for Mechanical Engineers, 2015, ISBN:9780791869741.
5. American Petroleum Institute, "Specification for Line Pipe" American Petroleum Institute Standard Specifications 5L, 38th Edition, 2012, ISBN: 9789997820570.
6. American Petroleum Institute, "Welding of Pipelines and Related Facilities", American Petroleum Institute Standard 1104, American Petroleum Institute,20th Edition, 2006, ISBN: 9780871710499.
7. American Welding Society, "Structural Welding Code – Steel AWS D1.1", American Welding Society,2015, ISBN: 9780871718648.

Web Resources

1. NPTEL MOOC Course on "Analysis and Modeling of Welding"
(https://onlinecourses.nptel.ac.in/noc16_mm02/preview)
2. NPTEL MOOC Course on "Analysis and Modeling of Welding"
(https://onlinecourses.nptel.ac.in/noc17_mm06/preview)
3. NPTEL MOOC Course on "Joining Technologies for Metals"
(https://onlinecourses.nptel.ac.in/noc17_me09/preview)

DEPARTMENT OF MATERIALS AND METALLUGICAL ENGINEERING
INDUS INSTITUTE OF TECHNOLOGY AND ENGINEERING
INDUS UNIVERSITY

Subject: **Minor Project**								
Program: **B. Tech in Metallurgical Engineering**				Subject Code: **MME0711**			Semester: **VII**	
Teaching Scheme (Hours per week)				**Examination Evaluation Scheme (Marks)**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
0	0	6	3	0	16/40	0	24/60	100

DEPARTMENT OF MATERIALS AND METALLUGICAL ENGINEERING
INDUS INSTITUTE OF TECHNOLOGY AND ENGINEERING
INDUS UNIVERSITY

Subject: **Failure Analysis (OE–8)**								
Program: **B. Tech in Metallurgical Engineering**				Subject Code: **MME0716**			Semester: **VII**	
Teaching Scheme (Hours per week)				**Examination Evaluation Scheme (Marks)**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	0	0	3	16/40	0	24/60	0	100

Course Objectives

1. To impart the broad knowledge of failure analysis.
2. To introduce the tools and techniques for failure analysis.
3. To understand various failure mechanisms for engineering materials.

CONTENTS

UNIT-I

[10 hours]

Importance of failure analysis and its relationship to material selection, fundamental causes of failure, imperfections in base metals, Poor assembly, service and maintenance. General practice in failure analysis. Tools and techniques for failure analysis.

UNIT-II

[10 hours]

Failure- types and characteristics: Identification and characterization of ductile and brittle type of failures. Ductile to Brittle fracture, factors contribute for DBTT. Fracture mechanism, fracture modes and micro fractographic features. Case studies.

UNIT-III

[10 hours]

Concept and Mechanism of Failure: Identification and characterization of fatigue failures, types of fatigue, corrosion fatigue and contact fatigue. Case studies.

UNIT-IV

[10 hours]

Creep failure, creep test. Corrosion and corrosion related failures such as hydrogen embrittlement, stress corrosion cracking and high temperature failures. Case studies

Course Outcomes

1. To develop basic scientific principles and engineering fundamentals necessary to formulate, analyze and solve engineering & technical problems & demonstrate the ability to synthesize data and technical concepts for application to product design & developments.
2. To analyze and apply their understanding in order to perform failure analysis of various engineering materials and components.

Text Books

1. Donald J. Wulpi, "Understanding How Components Fail".
2. V.J. Colangeloand F.A. Heiser, "Analysis of Metallurgical Failures", Wiley-Interscience, 2nd Edition, 1987, ISBN: 9780471891680.
3. C. R. Brooks and A. Chaudhary, "Failure Analysis of Engineering Materials", McGraw-Hill Education, 1st Edition, 2001, ISBN: 9780071357586.
4. A.K. Das, "Metallurgy of Failure Analysis", McGraw-Hill Professional, 1st Edition, 1997, ISBN: 9780070158047.

Reference Books

1. American Society of Metals, "Metals Handbook –Failure Analysis and Prevention", American Society of Metals, 8th Edition, 1975, ASIN: B0026SIT3E.
2. American Society of Metals, "Metals Handbook – Fractography and Atlas of Fractographs", American Society of Metals, 8th Edition, 1974, ASIN: B000I1VM9Y.

Web Resources

1. NPTEL online course on "Failure analysis and prevention" (https://nptel.ac.in/courses/112/107/112107241/)

DEPARTMENT OF MATERIALS AND METALLUGICAL ENGINEERING
INDUS INSTITUTE OF TECHNOLOGY AND ENGINEERING
INDUS UNIVERSITY

Subject: **Introduction to Non Destructive Evaluation (OE–9)**								
Program: **B. Tech Metallurgical Engineering**				Subject Code: **MME0713**			Semester: **VII**	
Teaching Scheme (Hours per week)				**Examination Evaluation Scheme (Marks)**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	0	0	3	16/40	0	24/60	0	100

Course Objectives

1. To understand the significance of testing of metallic and non-metallic materials and components without destroying them.
2. To study the application of these methods in assessing reliability of components & plants.
3. To study the life time assessment of components.

CONTENTS

UNIT-I

[10 hours]

Fundamentals and introduction to non-destructive testing. Scope and limitations of NDT Visual examination methods. Different visual examination aids.

Leak and pressure testing of industrial components. Various methods of pressure and leak testing underlying principles of these testing systems.

UNIT-II

[10 hours]

Dye penetrant Methods, Basic Principles, Capillary Action, Wetting and Non-Wetting Characteristics, Different Types of Penetrants, Detailed Procedure and Recent Developments in DPT.

Magnetic Particle Testing methods, Basic Principles of MPT, magnetization methods demagnetization methods, MPT equipment & instruments.

Ultrasonic methods of NDT-Basic principles of wave propagation, types of waves, transducers and transducer materials, advantages and limitations of UT.

UNIT-III

[10 hours]

Pulse Echo and Through Transmission techniques of UT, Calibration methods, use of standard blocks, Thickness determination by ultrasonic method. Study of A, B and C scan presentations.

Radiographic testing of metallic components. X-ray and Gamma-Ray radiography. Their principles, methods of generation. Industrial radiography techniques. Types of films, screens and penetrameters.

UNIT-IV

[10 hours]

Eddy current testing: Basic principles and applications such as detection of defects and characterization, sorting of materials, determination of film/coating thickness, measurement of electrical conductivity and magnetic permeability of materials.

Acoustic Emission Technique. Conductivity & resistivity methods and their applications. Thermal methods of NDT.

Selection Criteria for various NDT techniques.

Course Outcomes

1. To understand the principle and application of visual testing methods.
2. To understand principle of liquid penetration testing technique.
3. To understand the principle of magnetic particle testing and its applications.

Text Books

1. B. Raj,T. Jayakumar and M. Thavasimuthu, "Practical Non-Destructive Testing",Norosa Publishing House, 3rd Edition, 2014, ISBN: 9788173197970.
2. W. J. McGonnagle, "Non Destructive Testing", Routledge, 1stEdition, 1971, ISBN: 9780677005003.

Reference Books

1. J. Krautkramer, "Ultrasonic Testing of Materials", Allen & Unwin, 2nd Edition, 1969, ISBN: 9780046200015.
2. J. Prasad and C. G. K. Nair, "Non-Destructive Test and Evaluation of Materials",McGraw Hill Education, 2nd Edition, 2011, ISBN: 9781259061615.
3. R. Halmshaw, "Non-Destructive Testing (Metallurgy and Materials Science)", Butterworth-Heinemann, 2nd Edition, 1991, ISBN: 9780340545218.
4. L. Filipczynski, Z. Pawłowski and J. Wehr, "Ultrasonic Methods of Testing Materials", Butterworth, 1st Edition, 1966, ASIN: B00MJ3OOIU.

Web Resources

1. NPTEL MOOC Course on "Theory and Practice of Non Destructive Testing" (https://onlinecourses.nptel.ac.in/noc16_mm07/preview)

8TH SEMESTER

DEPARTMENT OF MATERIALS AND METALLUGICAL ENGINEERING
INDUS INSTITUTE OF TECHNOLOGY AND ENGINEERING
INDUS UNIVERSITY

Subject: **Research Project**								
Program: **B. Tech Metallurgical Engineering**				Subject Code: **MME0801**			Semester: **VIII**	
Teaching Scheme (Hours per week)				**Examination Evaluation Scheme (Marks)**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
0	0	24	12	0	16/40	0	24/60	100