MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

DEPARTMENT OF METALLURGICAL AND MATERAILS ENGINEERING

Curriculum structure For B.Tech. Honours Degree

Semester V

S. N.	Course Code	Course Title	Category	L	T	P	Credits	Contact Hrs	Total Credits
1		**Program Elective- VIII**	PE	3	0	0	3		
2		**Program Elective- IX**	PE	3	0	0	3		

Semester VI

1		**Program Elective- X (from M.Tech. electives)**	PE	3	0	0	3		
2		**Program Elective- XI**	PE	3	0	0	3		

Semester VII

1		**Program Elective-XII (from M.Tech. courses)**	PE	3	0	0	3		

Semester VIII

1		**Program Elective-XIII (from M.Tech. courses)**	PE	3	0	0	3		

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Convener, DUGC

ELECTIVES

ENGINEERING METALS		EXTRACTIVE METALLURGY	
22MTT809	Light Metals and Alloys	22MTT802	Alternative Routes of Iron making
22MTT804	Design and Development of Steels	22MTT814	Secondary Steel Making
22MTT816	Theory of Alloy Design	22MTT806	Extraction of Mg, Sn, Ferro-Alloying Elements, Ni, Ti
22MTT813	Physical Metallurgy of Alloy Steels	22MTT805	Environment and Waste Management in Metallurgical Industries
22MTT826	High Temperature Corrosion	**PROCESS METALLURGY**	
22MTT808	Fracture and Failure	22MTT810	Metallurgy of Additive Manufacturing
22MTT807	Fatigue, Fracture and Creep	22MTT828	Particulate Materials
22MTT803	Defects and Diffusion in Crystalline solids	22MTT817	Welding Metallurgy
22MTT827	Introduction to Computational Materials Science	22MTT801	Advanced Casting Technology
ENGINEERING MATERIALS		22MTT818	Additive Manufacturing Process
22MTT310	Composite Materials	22MTT811	Non-Equilibrium Processing of Materials
22MTT821	Automotive and Aerospace Materials	22MTT815	Surface Engineering
22MTT829	Properties and Processing of Polymers		
22MTT830	Tribological Engineering Materials		
22MTT820	Advanced Solar Photovoltaic Materials and Technologies		
22MTT823	Ceramics and Glasses		
22MTT822	Biomaterials		
22MTT812	Nuclear Materials		
22MTT824	Design and selection of materials		
22MTT825	Electronic and Magnetic Materials		
22MTT819	Advanced Microscopic Techniques		

Prof. Upender Pandel

(Head of the Department)

Dr. Sreekumar Vadakke Madam

(DUGC Convener)

DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING
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EXTRACTIVE METALLURGY

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DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT802	**Alternative Routes of Iron making**	**3**	**3**	**0**	**0**	**0**

PREREQUISITE: Iron Making, Production of Sponge Iron and Ferroalloys.

COURSE OBJECTIVE:

- To provide basic understanding on various alternative iron making routes such as coal and gas based DRI making and smelting reduction processes.

COURSE OUTCOMES:

CO1	Sketch operational aspects of various coal and gas based DRI making technologies.
CO2	Understand various storage, transportation and operational issues with respect to DRIs.
CO3	Understand the development in various smelting reduction processes.
CO4	Understand the fundamentals of physic- chemical principles involved in iron ore reduction in solid and liquid state.

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I: Need for the development of alternative routes, approaches towards new techniques. Classification of advanced processes. Thermodynamic and kinetic aspects of iron ore reduction in solid and liquid state using solid/gaseous reductants.

(No. of Lectures - 8)

Unit II: Sponge iron production using shaft, kiln, retort and rotary hearth reactors. Raw materials preparation. Selection of reductants. Heat and mass transfer. Energy consumption and operating problems. Storage, transportation and utilization of sponge iron in India.

(No. of Lectures - 12)

Unit III: Pre- reduced iron ore pellets for blast furnace applications, concept of composite pellets and its feasibility. Iron powder and iron carbide preparation from fluidized bed reactor and other processes. Operating/ storage problems.

(No. of Lectures - 10)

Unit IV: Smelting- Reduction Processes: Principles, classification, merits and limitations. COREX process and electric smelting processes.

(No. of Lectures - 10)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Alternative Routes to Iron Making, A. Sarangi and B. Sarangi, 2nd edition, PHI Learning Private Limited, 2015.
2. Sponge iron production by direct reduction of iron oxide, A. Chatterjee, 2nd edition, PHI Learning Private Limited, 2012.
3. An introduction to modern iron making, R.H. Tupkary and V.R. Tupkary, 3rd edition, Khanna publishers, 2010.
4. Hot metal production by smelting reduction of iron oxide, A. Chatterjee, 1st edition, PHI Learning Private Limited, 2009.

ONLINE/E RESOURCES:

1. https: //nptel.ac.in

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DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT814	**Secondary Steel Making**	**3**	**3**	**0**	**0**	**0**

PREREQUISITE: Courses: Iron making, Steel making, Metallurgical thermodynamics and kinetics

COURSE OBJECTIVE:

- To teach the students about the importance, theories and practices of producing secondary steel.

COURSE OUTCOMES:

CO1	Understand the importance of secondary refining of steel.
CO2	Anlayse about inclusion control in steel.
CO3	Understand different theories behind secondary steel making.
CO4	Compare different processes of secondary steel making.
CO5	Understand recent advances in secondary steel making.

COURSE ASSESSMENT:

The Course assessment (culminating to the final grade), will be made up of the following components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I: Brief Review of primary steel making processes, limitation of primary steelmaking & importance of secondary steel making, objectives of secondary steel making processes, secondary steel making reactor.

(No. of lectures- 7)

Unit II: Furnace tapping operations, prevention of slag carryover, principles of deoxidation, desulphurization and inclusion control, injection metallurgy and its usefulness, ladle refining technique with synthetic slag practice.

(No. of lectures- 8)

Unit III: Effect of agitation of bath in ladle metallurgy operation- different processes of argon stirring and their relative merits, vacuum metallurgy – Sievert's law, vacuum carbon deoxidation; vacuum oxygen decarburization, argon oxygen decarburization, vacuum degassing of steel, tank degassing, stream degassing, recirculation degassing- RH and DH processes.

(No. of lectures- 10)

Unit IV: Refining of steel by remelting under vacuum: CEVAM process, electro slag refining technique, advantages of the process and their limitations, ladle metallurgy as secondary refining process - vacuum arc degassing, ASEA- SKF process, evaluation of ladle metallurgy from the view point of production high quality ultraclean steel.

(No. of lectures- 10)

Unit V: Recent advances in secondary steel making.

(No. of lectures- 5)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Secondary Steelmaking: Principles and Applications, A. Ghosh, CRC Press, 2000.
2. Iron Making and Steelmaking: Theory and Practice, A. Chatterjee and A. Ghosh, PHI Learning Pvt. Ltd., 2008.
3. A First Course in Iron and Steel Making, D. Mazumdar, Universities Press, Hyderabad, 2015.

OTHER RESOURCES:

1. Recent journal papers
2. Expert lecture from industry persons

ONLINE RESOURCES

1. https://nptel.ac.in

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DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT806	**Extraction of Mg, Sn, Ferro- Alloying Elements, Ni, Ti**	**3**	**3**	**0**	**0**	**0**

PREREQUISITE: Mineral Processing, Introduction to Extractive Metallurgy

COURSE OBJECTIVE:

- To familiarize the students with basic knowledge about various non- ferrous metals and their route of extraction

COURSE OUTCOMES:

CO1	Select Pyrometallurgical, Hydrometallurgical & Electrometallurgical methods of extraction of Non- ferrous Metals.
CO2	Identify suitable processes of extraction depending on Non Ferrous Metals to be extracted.
CO3	Apply knowledge of various extraction processes to get final product.
CO4	Suggest proper non- ferrous metals for various applications

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I Extraction of Magnesium and Tin: Ores, methods of Mg extraction, Pidgeon process, Mg production in India, Concentration of Sn ores, smelting of Sn concentrate, refining of Sn.

(No. of lectures- 10)

Unit II Extraction of Ferro alloying Elements: Extraction of Chromium, Manganese, Silicon, Tungsten, Vanadium, Molybdenum, Tantalum.

(No. of lectures- 15)

Unit III Extraction of Nickel: Extraction of Ni by pyrometallurgy, Extraction of Ni from oxide ores, hydrometallurgy of nickel sulphide concentrates.

(No. of lectures- 8)

Unit IV Extraction of Titanium: Ores, treatment of Ilmenite for upgradation, chlorination of TiO_2, production of metallic Ti by reduction of titanium tetrachloride.

(No. of lectures- 7)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Extraction of Non- ferrous Metals, H.S. Ray, R. Sridhar and K.P. Abraham, Affiliated East West Press (P) Ltd., 2015
2. Extractive Metallurgy of Non- ferrous Metals, R. Raghvan, V. N. Publication, 2016
3. Non-ferrous Production Metallurgy – John L Bray John Wiley & Sons; First Edition, 1941

ONLINE/E RESOURCES:

1. https://nptel.ac.in
2. Expert lectures from the industry

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DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT805	**Environment and Waste Management in Metallurgical Industries**	**3**	**3**	**0**	**0**	**0**

PREREQUISITE: Basic Sciences Basics in Metallurgical engineering processes and extractive metallurgy

COURSE OBJECTIVE:

- To provide background and details of the various waste management techniques applied in metallurgical engineering industries

COURSE OUTCOMES:

CO1	Understand the working principles of waste management techniques in metallurgical industries
CO2	Analyse the root cause of the pollution created in metallurgical industries by metallurgical wastes

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I: Sources and classification of pollutants, Metallurgical factors influencing air, water and soil pollution

(No. of Lectures - 10)

Unit II: Control of pollution by equipments. Cleaner Production (Pollution Control) in Metallurgical Industries

(No. of Lectures - 10)

Unit III: Iron and Steel and Non- ferrous Metals (Cu, Al, Zn, and Pb), Pollution Control in ferrous & non-ferrous foundries, effluent treatment and recycling of metals from ferrous and Non-ferrous industry and e-waste.

(No. of Lectures - 8)

Unit IV: Introduction to need of environmental management. Policies, procedures and resources for implementing and maintaining effective environmental management in the organization. ISO: 14000, of waste & its disposal and light weighting in transport.

(No. of Lectures - 12)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Dust & Fume Generation in the Iron & Steel Industries, S. Andoneyev, O. Filipyev.
2. Air Pollution, M.N. Rao, HVN Rao
3. Environmental Engineering, G.N.Pandey.

ONLINE RESOURCES

1. https://nptel.ac.in

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PROCESS METALLURGY

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DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT810	**Metallurgy of Additive Manufacturing**	**3**	**3**	**0**	**0**	**0**

PREREQUISITES: Introduction to Physical Metallurgy

COURSE OBJECTIVES:

- To educate students the microstructural changes that take place during Additive manufacturing.

COURSE OUTCOMES:

CO1	Understand physical metallurgy of strengthening mechanism of metals.
CO2	Understand the solidification of metals and segregation mechanism
CO3	Familiarize various cracking and fracture during solidification
CO4	Analyze the microstructure evolution, solidification and issues during 3D printing

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following three components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

UNIT I Introduction to Physical Metallurgy: Mechanical properties of metals, dislocations and strengthening mechanisms, failure, grain structure and recrystallization, phase diagrams, phase transformations: development of microstructure and alteration of mechanical properties, strengthening mechanisms.

(No. of lectures- 6)

UNIT II Solidification of Metals: Solidification of metals, interface stability, microscopic aspects of solidification, solute redistribution: macroscopic and microscopic, segregation mechanism, recrystallization and grain growth, allotropic transformation, precipitation reactions, Fracture toughness, Solidification cracking, reheat cracking, liquation cracking, cold cracking, strain- age, and ductility dip cracking.

(No. of lectures- 8)

UNIT III Metallurgy of Steel: Introduction of additive manufacturing of steel, physical and mechanical metallurgy of austenitic and PH steels solidification mode in austenitic and PH steels, processing issues with 3D printing of steel, case study on metallurgical aspects using laser based process.

(No. of lectures- 7)

UNIT IV Metallurgy of Nickel based alloys: Nickel base alloy classification, physical and mechanical properties of precipitation based- strengthened Nickel based alloys, solidification and microstructure evolution, processing issues, case study on metallurgical aspects using arc based process.

(No. of lectures- 7)

UNIT V Metallurgy of Titanium based alloys: Titanium base alloy classification, physical and mechanical properties of alpha beta titanium alloys, solidification and microstructure evolution, processing issues, case study on metallurgical aspects using electron beam based process

(No. of lectures- 6)

UNIT VI Post Processing treatment for property improvement: Thermal post processing, hot isostatic pressing, recrystallization, stress relieving, solution treatment and aging.

(No. of lectures- 6)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Metallurgy and mechanics of welding: processes and industrial applications. Blondeau, Régis, John Wiley & Sons, 2013.
2. Welding Metallurgy and Weldability of Stainless Steels, by J. C. Lippold, D.J. Kotecki, Wiley, 2005.
3. ASM Hand book – Surface Engineering, ASM International, Vol. 5, 1994.
4. Welding metallurgy and weldability of nickel- base alloys, Lippold, J.C., Kiser, S. D., & DuPont, J.N, John Wiley & Sons, 2011.

ONLINE/E- RESOURCES

1. https: //www.coursera.org/learn/additive- technologies- in- metallurgy- - mechanical-engineering
2. https://nptel.ac.in

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DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT828	**Particulate Materials**	**4**	**3**	**1**	**0**	**0**

PREREQUISITES: Manufacturing, Physical Metallurgy

COURSE OBJECTIVES:

- To learn and get an in depth understanding in a scientific and systematic manner, which includes understanding various powder metallurgy principles
- To provide with knowledge about the field of powder metallurgy and teach them generic principles associated with creating powders and fabricating engineering shapes from those powders.

COURSE OUTCOMES:

CO1	Understand the key concepts and terminology in the field of powder metallurgy
CO2	Describe and explain different powder production techniques, compaction and shaping, sintering and finishing of the powder metallurgical components
CO3	Relate the microstructure and mechanical properties of powder metallurgy components in relation to their applications

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I Introduction: Introduction to powder metallurgy. Powder Production: General principles of mechanical, chemical, atomization and electrolytic method of metal and alloy powders production.

(No. of lectures - 8)

Unit II Powder Characterization: Chemical composition, Microstructure, size and size distribution, shape, surface area, flow rate, apparent and tap density. Compressibility, pyrophoricity and toxicity of metallic powders, powder annealing.

(No. of lectures - 8)

Unit III Powder Processing: Mixing and blending and their mechanics, powder mixers, mechanical alloying. Cold compaction: Compaction in rigid dies, uniaxial and biaxial compaction, mechanical and hydraulic presses.

(No. of lectures - 8)

Unit IV Sintering and Hot Compaction: Sintering: Basic stages of sintering and mechanisms involved, liquid phase sintering, solid state sintering, sintering furnaces, sintering atmospheres. Hot pressing, powder compact extrusion, powder compact forging, powder compact rolling. Powder injection moulding, hot isostatic pressing, additive manufacturing.

(No. of lectures - 10)

Unit V Applications: Near net shape technology, Cemented carbides, bearing materials, sintered friction materials- clutches, brake linings, Bushes, filters, and bioimplants, dispersion strengthened materials, cemented carbides.

(No. of lectures - 6)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Introduction to Powder Metallurgy, J.S. Hirschoron, American Powder Metallurgy Institute, 1st Edition 1969
2. Powder Metallurgy Science, R.M. German, Metal Powder Industry; Subsequent edition,1994
3. Powder Metallurgy: Principles & Applications, F.V.Lenel –Metal Powder Industry; 1st Ed., 1980
4. Powder Metallurgy, P.C. Angelo & R. Subramaniam, PHI Learning Pvt. Ltd., Eastern economy Edition, 2008
5. Powder Metallurgy for Engg., R.H.T. Dixon & A. Clayton, Machinery Publishing, 2011.
6. Powder Metallurgy, K. Sinha, Dhanpat Rai Publications, New Delhi, 2nd edition, 2016.
7. Powder Metallurgy, ASM Hand Book, Volume 7, 2015.

ONLINE/E RESOURCES

1. Powder Metallurgy (NPTEL Course) by Ranjit Bauri (IITM)
2. https://onlinecourses.nptel.ac.in/

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DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT817	**Welding Metallurgy**	**4**	**3**	**1**	**0**	**0**

PREREQUISITE: Joining of metals

COURSE OBJECTIVE:

To gain knowledge about welding techniques and the associated metallurgy of steel weld

COURSE OUTCOMES:

CO1	Understand the importance of the welding in structural applications
CO2	Acquire knowledge of welding microstructures and properties of steel

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I: Overview of welding, Importance of welding in structural applications, joining efficiency

(No. of lectures - 2)

Unit II: Fusion welding techniques such as submerged arc welding, flux core arc welding, tungsten inert gas welding, Metal inert gas welding, plasma arc welding, electron beam welding, laser beam welding. Solid state welding, Heat Source, Heat flow in welding, Analysis of Heat Flow in Welding, Effect of Welding Parameters, Chemical Reactions in Welding, Gas–Metal Reactions, Slag–Metal Reactions

(No. of lectures - 15)

Unit III: Fluid Flow and Metal Evaporation in Welding, Residual Stresses, Distortion, and Fatigue, Weld Metal Solidification, Grain Structure, Microstructure within Grains, Post-Solidification Phase Transformations, Weld Metal Chemical In homogeneities

(No. of lectures –13)

Unit IV: Weld Metal Solidification Cracking, Characteristics, Cause, and Testing, Metallurgical Factors, Mechanical Factors, Reducing Solidification Cracking, Formation of the Partially Melted Zone, Difficulties Associated with the Partially Melted Zone, Case studies .

(No. of lectures - 10)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Welding Metallurgy, Sindo Kou, A. John Wiley and Sons, Inc., 2003.
2. Welding Metallurgy and Weldability, J. C. Lippold, John Willey and Sons, New Jersey, United States 2015

ONLINE/E RESOURCES:

1. https://nptel.ac.in

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DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT801	**Advanced Casting Technology**	**3**	**3**	**0**	**0**	**0**

PREREQUISITES: Foundry Technology, Physical metallurgy

COURSE OBJECTIVES:

- To provide the knowledge and practice regarding different foundry processes and their industrial importance
- To provide knowledge on efficient design of casting runner, riser and gating system with minimal casting defects and solidification process

COURSE OUTCOMES:

CO1	Understand the fundamental knowledge on the casting systems
CO2	Analyze gating and riser design and the metallurgical aspects of the solidified metals
CO3	Sketch castability- process friendly design
CO4	Describe the inspection and testing of different castings

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following components:

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quizzes	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I: Casting Processes, classification, characteristics of sand casting processes, metal mould casting processes and casting processes using other mould/core materials, Pattern materials, types of patterns, Mould and core making materials and their characteristics.

(No of Lecture - 5)

Unit II: Technology of Selected Casting Processes, Sand mould casting processes, Metal mould casting processes, centrifugal casting, continuous casting processes, Direct Chill casting, High Pressure and low pressure casting

(No of Lecture - 8)

Unit III: Casting for heterogeneous materials- Fiber Reinforcement Plastics, quick casting, full mould casting, evaporative pattern casting

(No of Lecture - 7)

Unit IV: Solidification, gating and risering design and analysis, nucleation and grain growth, solidification of pure metals, short and long freezing range alloys. Rate of solidification, macrostructure and microstructure. Solidification contraction, fluidity and its measurement. Mould-metal interface reactions, Directional solidification.

(No of Lecture - 10)

Unit V: Melting and quality control of various steels and non- ferrous alloys - casting defects - fettling, inspection and testing of castings Design for castability - process friendly design, castability analysis, repair & salvage, advancement in casting.

(No. of Lectures - 10)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Complete Casting Handbook: Metal Casting Processes, Metallurgy, Techniques and Design, John Campbell, Butterworth- Heinemann, 2015
2. Manufacturing processes for Engineering Materials, Serope Kalpakjian, Addision, Wesley, 1997.
3. Fundamentals of metal casting technology, P.C. Mukherjee, Oxford & IBH Publishing Company, 1988
4. Casting properties of metals and alloys, A.M. Korolkov Consultants Bureau, 1963
5. Casting, ASM Handbook Volume 15, 2008

ONLINE RESOURCES:

1. https://nptel.ac.in

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DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT818	**Additive Manufacturing Process**	**3**	**3**	**0**	**0**	**0**

PREREQUISITES: Basics of engineering materials, manufacturing process

COURSE OBJECTIVES:

- To educate students with fundamental and advanced knowledge in the field of Additive manufacturing technology

COURSE OUTCOMES:

CO1	Understand the working principles and process parameters of additive manufacturing processes
CO2	Distinguish different additive manufacturing processes and suggest suitable methods for building a particular component
CO3	Design and develop a working model using additive manufacturing processes

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Weekly submissions/ assignments/ quizzes	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I Introduction to Additive Manufacturing: Introduction to AM, AM evolution, Distinction between AM & CNC machining, Steps in AM, Classification of AM processes, Advantages of AM and types of materials for AM.

(No. of lectures - 4)

Unit II Additive Manufacturing Methods: Vat Photo- polymerization: Material Jetting: Material extrusion: Binder Jetting: Sheet Lamination: Powder Bed fusion: Direct Energy Deposition: discuss on process mechanism, process parameters, advantages, limitations, applications, recent advances; other similar Processes: thermal spray direct writing, beam deposition, liquid phase deposition, hybrid techniques

(No. of lectures - 16)

Unit III Additive Manufacturing Equipment and Sub- systems: Laser: Laser fundamentals, construction of laser systems, laser properties, laser material interaction, types of laser; Electron Beam: Fundamentals, electron beam –metal interaction, electron beam based additive manufacturing systems Arc- based AM: process mechanism, process parameters, advantages, limitations, applications, recent advances Beam, Material Feeding and Job Manipulation System: laser beam scanning, laser optics, fibre delivery system, job manipulation, electron beam manipulation, process chambers, sensors, material feeding systems, co- axial and lateral nozzles, powder spreading, multi- material spreading.

(No. of lectures - 7)

Unit IV Additive Manufacturing Materials: Types of materials, Polymer, Metals, Ceramics, recent advances in materials, forms of raw materials, support materials, powder production techniques, and powder characterization.

(No. of lectures - 3)

Unit V Post-Processing: Support material removal, surface texture improvement, accuracy improvement, aesthetic improvement, preparation for use as a pattern, property enhancements using non- thermal and thermal techniques.

(No. of lectures - 6)

Unit VI Guidelines for Process Selection: Selection methods for a part, challenges of selection, example system for preliminary selection, process planning and control.

(No. of lectures - 4)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Additive Manufacturing: Principles, Technologies and Applications, C.P Paul, A.N Junoop, McGraw-Hill, 2021
2. Additive Manufacturing, Second Edition, Amit Bandyopadhyay Susmita Bose, CRC Press Taylor & Francis Group, 2020.
3. Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing, Ian Gibson, David W Rosen, Brent Stucker, Springer, 2015, 2nd Edition.
4. 3D Printing and Additive Manufacturing: Principles & Applications, Chua Chee Kai, Leong Kah Fai, World Scientific, 2015, 4th Edition.
5. Rapid Prototyping: Laser- based and Other Technologies, Patri K. Venu Vinod and Weiyin Ma, Springer, 2004.

ONLINE/E RESOURCES

1. https://www.nist.gov/additive- manufacturing
2. http://additivemanufacturing.com/basics/
3. https://nptel.co.in

DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Scheme/Specialization: B.Tech. (Metallurgical and Materials Engineering)

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT811	**Non-Equilibrium Processing of Materials**	**3**	**3**	**0**	**0**	**0**

PREREQUISITE: Basic of thermodynamics, manufacturing processes

COURSE OBJECTIVE:

- To familiarize and equip the students with knowledge of principles and techniques of non- equilibrium processes those are on the threshold of development of materials for the new millennium.

COURSE OUTCOMES:

CO1	Understand the rapid technological developments during recent decades.
CO2	Understand the development of materials that are stronger and capable of use at high temperature and are less expensive.
CO3	Identify the potentials and limitation of the processes and techniques that enable the prospective scientists who wish to enter into the area of non- equilibrium processing

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following components.

S. No.	Component	Weightage
a)	Weekly submissions/ assignments/ quizzes	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I: Thermodynamics and Kinetics of Metastable Phase Transformation: Free energy of elements and alloys. Free energy determination of metastable phases. Supersaturated phases and their lattice parameters. Kinetics of Metastable Phase Formation – Nucleation and Growth.

(No. of lectures - 7)

Unit II: Introduction to non- equilibrium materials processing route: rapid solidification, spray forming, mechanical alloying, ion mixing, vapour deposition, laser processing, plasma processing Sputtering systems, ECAPs, Roll bonding, Friction based processes like friction welding, friction stir processing, friction surfacing.

(No. of lectures - 7)

Unit III: Basic principles of the processes: Basic thermodynamic and kinetic aspects related to the microstructure development during non- equilibrium processing. Effect of fine structures on equilibrium, suppressing of equilibrium structures.

(No. of lectures - 6)

Unit IV: Nanostructured Materials: Preparation, Structure, Stability, Particle consolidation, Properties, Applications – present and potentials, Powder Consolidation.

(No. of lectures - 6)

Unit V: Bulk Amorphous Alloys, Quasicrystals, High entropy alloys. atomic crystals and their reactivity. Non- equilibrium phases in Fe based, Cu based, Al based alloys.

(No. of lectures - 10)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Non- equilibrium Processing of Materials, C. Suryanarayana, Elsevier publications, 1st Edition - July 22, 1999 ISBN: 9780080426976
2. Friction stir processing and Applications, Rajiv Mishra, Elsevier publications, 2005.
3. Tribology in manufacturing technology, D. J. Paulo, Springer, 2012.
4. Laser surface processing and model studies, B. S. Yilbas, S Z Shuja Springer, 2013.
5. An introduction to surface alloying of metals, S. Hosamani 2011.

ONLINE/E RESOURCES:

1. https://nptel.co.in

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DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT815	**Surface Engineering**	**3**	**3**	**0**	**0**	**0**

PREREQUISITES: Introduction to Engineering Materials

COURSE OBJECTIVES:

- To establish a fundamental understanding of materials and their roles in surface selection for target applications.
- To introduce the concept of surface engineering and its importance

COURSE OUTCOMES:

CO1	Analyze the factors responsible for surface damage by corrosion, wear, and wear mechanisms.
CO2	Apply the fundamentals of surface engineering.
CO3	Apply the knowledge and grasp of coating deposition concepts.

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following three components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quizzes	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I Introduction: General introduction to surface and bulk, microstructure, properties, interfaces, defects, importance of substrate, current status of surface engineering, introduction to tribology, surface degradation by wear and corrosion.

(No. of Lectures - 5)

Unit II Surface Degradation by Wear: Friction, wear, lubrication, roles of friction and lubrication, categories of wear, wear and lubrication mechanisms, wear and lubrication mode, an overview of lubrication.

(No. of Lectures - 6)

Unit III Surface Degradation by Corrosion: Corrosion mechanisms, oxidation and related concepts, the interaction between wear and corrosion.

(No. of Lectures - 6)

Unit IV Surface Coating Processes: Gaseous state processes – chemical vapor deposition, physical vapor deposition, Ion and laser beam- assisted deposition and surface treatment; solution state processes – chemical solution deposition, electrochemical deposition, sol- gel processing, plasma electrolysis; molten and semi- molten processes – laser surface treatment, thermal spraying, welding; surface hardening treatment.

(No. of Lectures - 10)

Unit V Surface Characterizations: Coating characteristics: surface, thickness, adhesion, morphology, composition, wettability, residual stress, Property characterization and evaluation: roughness, thickness, Microhardness & nanoindentation, tribological evaluation, visual and metallurgical examinations, optical and electron microscopy.

(No. of Lectures - 8)

Unit VI Industrial Applications: Sliding bearings, rolling contact bearings, gears, tools for cutting, tool forming, erosion and scratch- resistant surfaces, magnetic recording devices, etc.

(No. of Lectures - 5)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Coatings Tribology: Properties, Mechanisms, Techniques, and Applications in Surface Engineering, K. Holmberg and A. Matthews, Elsevier, UK, 2009.
2. Corrosion Engineering, M.G. Fontana, Tata McGraw- Hill, 3rd ed. (seventh reprint), 2008.
3. Principles and Prevention of Corrosion, D. A. Jones, Prentice- Hall, 1996.

ONLINE/E RESOURCES

1. https://nptel.ac.in

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ENGINEERING METALS

DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING

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Scheme/Specialization: B.Tech. (Metallurgical and Materials Engineering)

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT809	**Light Metals and Alloys**	**3**	**3**	**0**	**0**	**0**

PREREQUISITE: Introduction to Physical Metallurgy, Principles of Heat Treatment, Mechanical Working of Metals

COURSE OBJECTIVE:

- To impart knowledge on processing, microstructure and properties of various important light metals and alloys being used by mankind today.

COURSE OUTCOMES:

CO1	Understand the importance of light metals and alloys.
CO2	Correlate the processing, properties and applications of Al and its alloys.
CO3	Distinguish the processing, properties and applications of Mg and its alloys.
CO4	Understand the processing, properties and applications of Ti and its alloys.
CO5	Understand the processing and properties of Be and Li alloys.

COURSE ASSESSMENT:

The Course assessment (culminating to the final grade), will be made up of the following components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I: General introduction, production, processing, and properties of light metals and alloys, applications.

(No. of Lectures - 6)

Unit II: Physical and mechanical metallurgy of aluminium and aluminium alloys, Nomenclature of Al alloys, Classification of aluminium alloys, Wrought and cast aluminium alloys, Work hardening, Annealing and age hardening of aluminium alloys.

(No. of Lectures - 9)

Unit III: Physical and mechanical metallurgy of magnesium and magnesium alloys, Alloying behaviour, Classification, Deformation behaviour, Effect of crystallographic texture on properties.

(No. of Lectures - 9)

Unit IV: Physical and mechanical metallurgy of titanium and titanium alloys, Classification of titanium alloys such as near α, α alloys, α/β alloys, β alloys, Titanium aluminides.

(No. of Lectures - 9)

Unit V: Beryllium and Li alloys, Rapid solidification, Future aspects and challenges.

(No. of Lectures - 7)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Light alloys: From Traditional Alloys to Nanocrystals, I. J. Polmear, 4th edition, Elsevier, 2006.
2. Physical Foundations of Materials Science, G. Gottstein, 1st edition, Springer, 2004.
3. Engineering Materials and Processes: Titanium, G. Lütjering and J. Williams, 2nd edition, Springer, 2007.
4. Magnesium Alloys and Technology, K. U. Kainer, 1st edition, Wiley, 2003.
5. ASM Handbook, Volume 9: Metallography and Microstructures, 2020.
6. ASM Handbook, Volume 2A: Aluminium Science and Technology, 2020.
7. ASM Handbook, Volume 2: Properties and Selection: Nonferrous Alloys and Special-Purpose Materials, 2020.

ONLINE RESOURCES

1. https://nptel.ac.in

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Scheme/Specialization: B.Tech. (Metallurgical and Materials Engineering)

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT804	**Design and Development of Steels**	**3**	**3**	**0**	**0**	**0**

PREREQUISITE: Basic Knowledge of Physical and Mechanical Metallurgy

COURSE OBJECTIVE:

To know various types of steels, their microstructure and properties.

COURSE OUTCOMES:

CO1	Identify various types of steel
CO2	Sketch the heat treatment routes to control microstructures

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I: Design rationales of steels for various engineering applications. Factors influencing the design of steels. Microstructural aspects of steel for use at low temperatures, high temperatures, and under corrosive atmosphere.

(No. of Lectures - 12)

Unit II: Development of steels for high strength, and high toughness applications requiring high ballistic properties.

(No. of Lectures - 5)

Unit III: Development strategies for cryogenic steels, creep resistant steels. Design of steels for wear resistant applications, cold-rolled grain-oriented steel (CRGO) & Cold Rolled Non-Oriented Coil (CRNO).

(No. of Lectures - 10)

Unit IV: Development of high performance steels e.g. TRIP steel and TWIP steels, interstitial free steels, nitrogen steels and extra low carbon precipitation hardenable steels. Additive strengthening and toughening of steels. Design of nano grained steels.

(No. of Lectures - 13)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Principles of Heat Treatment of Steels, G. Krauss, American Society for Metals,1980
2. Advanced steels - The recent Scenario in Steels Science & Technology, Y. Weng, H. Dong, Springer- Verlag Berlin Heidelberg, 2011.
3. Physical Metallurgy and Design of Steels, F.B. Pickering, Applied Science Publishers, 1978
4. Heat Treatment, ASM, Metals Handbook: Vol. 4, 9th Ed.
5. ASM, Metals Handbook: Properties and selection, Vol. 1, 10th Ed.
6. The Physical Metallurgy of Steels, William C. Leslie, Hempisphere Publishing Corporation, 1981.

ONLINE/E RESOURCES:

1. https://nptel.ac.in

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DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT816	**Theory of Alloy Design**	**3**	**3**	**0**	**0**	**0**

PREREQUISITE: Introduction to Physical Metallurgy, Principles of Heat Treatment

COURSE OBJECTIVE:

- To provide the students with the knowledge of requirements and theory behind alloy design.

COURSE OUTCOMES:

CO1	Understand the requirements of alloy design.
CO2	Analyze different strengthening methods and their applicability.
CO3	Analyze the roles of matrix and second phase on overall properties of a material.
CO4	Understand the theory of alloy design for different applications.
CO5	Identify various technologically important alloys.

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I: Significance of alloy design, Steps in alloy design and toughening, comparative study of different strengthening methods (Substructure and interface modification, solution strengthening, precipitation strengthening, dispersion strengthening, composite strengthening).

(No. of Lectures - 7)

Unit II: Single phase, dual phase and multiphase alloys, Effect of matrix on properties of alloys, Effect of size, shape and distribution of second phase on mechanical properties of alloys

(No. of Lectures - 7)

Unit III: Microstructural engineering and alloy design for improvement of tensile strength, ductility, toughness, design of high toughness alloys for high temperature and low

temperature applications, Alloys for onshore and off shore applications, Alloys for wear applications, Alloy for chemical industry.

(No. of Lectures - 7)

Unit IV: Alloy design for fatigue strength, creep strength, fracture strength and corrosion resistance (Aqueous, Stress).

(No. of Lectures - 14)

Unit V: Technologically important alloys: high strength low alloy steel, stainless steel, high speed steel, maraging steel, and Hadfield manganese steel.

(No. of Lectures - 5)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Alloy and Microstructural Design, John K. Tien and George S. Ansell (Eds.), Academic Press, 1st Edition, 1976.
2. Alloy Design, S. Ranganathan, V.S. Arunachalam and R.W. Cahn (Eds.), Indian Academy of Science, Bangalore, 1981.
3. ASM Handbook, Vo. 1 & 2, Properties and selection: Metals Park, Ohio, 1990.
4. Selection of Materials for Component Design: Source Book, H.E. Boyer (Ed.), American Society for Metals, Metals Park, Ohio, 1984.
5. Material Selection in Mechanical Design, M.F. Ashby, Pergamon, New York, 1992.

ONLINE RESOURCES:

1. https://nptel.ac.in

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DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT813	**Physical Metallurgy of Alloy Steels**	**3**	**3**	**0**	**0**	**0**

PREREQUISITE: Introduction to Physical Metallurgy

COURSE OBJECTIVE:

- To understand the structure- property relationship of alloy steels for engineering applications

COURSE OUTCOMES:

CO1	Understand various types of alloy steel
CO2	Sketch heat treatment routes to control alloy steel microstructures that will provide customizable properties to the component for specific engineering applications
CO3	Classify different phase transformations involved in alloy steel

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I: Advantages of alloy steels over plain carbon steels, classification of alloy steels, Composition, properties and applications of some low alloy steels. Composition, properties and applications of some high alloy steels. Strengthening mechanisms in steels. Heat treatment of alloy steels.

(No. of Lectures - 12)

Unit II: Physical metallurgy of alloy tool steels of different varieties, microstructural variation with heat treatment and its impact on properties and application of steels such as cold work tool steel, hot work tool steels, water hardening tool steels, shock- resisting tool

steels, and high- speed steels. Physical metallurgy of advanced steel e.g. dual- phase steel, IF steel, high manganese steel, TRIP steel.

(No. of lectures - 15)

Unit III: Physical metallurgy of stainless steel and their classification, embrittlement in ferritic stainless steel, sensitization, and stabilization in austenitic stainless steel; stabilized austenitic alloys.

(No. of lectures - 10)

Unit IV: Composition, properties and applications of some alloy cast irons.

(No. of Lectures - 3)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Physical Metallurgy of Steels, William C. Leslie, McGraw Hill, 1981
2. ASM, Metals Handbook: Properties and selection, Volume 1
3. Introduction to Physical Metallurgy, Sidney H. Avner, McGraw Hill, 2017
4. Engineering Physical Metallurgy and Heat Treatment, Yu M. Lakhtin, Mir Publishers, 1980
5. Physical Metallurgy and The Design of Steels, F.B. Pickering, Applied Science Publishers Ltd., 1978
6. Cast Iron – Physical and Engineering Properties, H.T. Angus, Butterworths, 2013

ONLINE/E RESOURCES:

1. https://nptel.ac.in

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DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT826	**High Temperature Corrosion**	**3**	**3**	**0**	**0**	**0**

PREREQUISITES: Electrometallurgy and Corrosion

COURSE OBJECTIVES:

To introduce the concept of high- temperature corrosion.

COURSE OUTCOMES:

CO1	Understand the fundamental aspects of high- temperature corrosion.
CO2	Select materials based on the high- temperature service conditions and application region.
CO3	Understand high- temperature oxidation behavior of pure metals and alloys.

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following three components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I Introduction: General introduction to corrosion, definition of high- temperature corrosion, high- temperature corrosion phenomena, high- temperature materials, corrosive environments, high- temperature corrosion encountered in different application areas.

(No of Lectures - 5)

Unit II High- Temperature Electrochemistry: Electrochemical nature of molten salt corrosion, single potential of an electrode, equilibrium diagrams, Tafel relationship, polarization, electrochemical nature of metal oxidation, current- potential measurements on solid electrodes.

(No of Lectures - 8)

Unit III Oxidation of Metals and Alloys: Oxidation of pure metals at high temperatures, kinetics of oxide scale formation, systems with significant oxygen solubility's in the metal, and crack- forming systems, growth law – linear and parabolic, Pilling-Bed worth ratio. Oxidation of alloys, classification of reaction types, noble parent with base alloying elements, base parent with base alloying elements, protective oxide forming alloys (iron and nickel-based).

(No of Lectures - 10)

Unit IV Corrosion in Various Environments: High- temperature corrosion in sulfur-containing environments: metal- sulfur reactions, sulfidation kinetics, hot corrosion, type 1 and type II hot corrosion, basic and acidic fluxing. High- temperature corrosion in alkali and halogen- containing environments: metal- alkali and halogen reactions, cyclic chlorine corrosion, corrosion in molten salts and carbonates. High- temperature corrosion in carbon and nitrogen- containing environments: alloy resistance to carburization, metal dusting, mechanisms of metal dusting, and prevention mechanisms against metal dusting, internal nitridation, and the effect of internal nitridation on mechanical properties. Effect of hydrogen and water vapor on high- temperature corrosion of metals.

(No of Lectures - 12)

Unit V Case Studies: Metallurgical Industries.

(No of Lectures - 5)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. High Temperature Corrosion, P. Kofstad, Elsevier Applied Science, 1988.
2. Corrosion and Oxidation of Metals, U. R. Evans, Arnold Publ., London, 1981.
3. Corrosion Engineering, M.G. Fontana, Tata McGraw- Hill, 3rd ed. (seventh reprint), 2008.
4. Introduction to High Temperature Oxidation and Corrosion, A.S. Khanna, ASM International, Materials Park, Ohio, 2002.

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DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT808	**Fracture and Failure**	**3**	**3**	**0**	**0**	**0**

PREREQUISITES: Mechanical behavior of materials

COURSE OBJECTIVES:

- To develop an in- depth understanding of the fundamentals of fracture mechanics and their historical prospects.
- To familiarize the students with various tools used to characterize the fracture behaviour of materials.

COURSE OUTCOMES:

CO1	Understand fracture and failure modes and their significance in materials evaluation.
CO2	Analyze the crack behaviour in different loading conditions.
CO3	Understand the practical aspect of failure analysis.

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following three components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I Introduction: Basic Concepts in Fracture Mechanics - The geometry of stress and strain, elastic deformation, plastic, and elasto-plastic deformation, the concept of catastrophic failure.

(No. of Lectures - 8)

Unit II Failure: Definition and explanation of the term failure, Fundamental causes of failure, type- I and type- II failure, stress- concentration factor, defect tolerance approach.

(No. of Lectures - 6)

Unit III Fracture parameters: LEFM, Types of fracture, Modes of fracture, Fracture toughness, concept of stress intensity factor, KI_C, J Integral, factors influencing fracture toughness of engineering alloys.

(No. of Lectures - 12)

Unit IV Fractographic examinations: Fractography, trans-granular and inter-granular fracture, modes of fracture.

(No. of Lectures - 4)

Unit V Modes of fracture and failure: Failure by fatigue, creep, and corrosion, Stress corrosion cracking. Failure due to faulty selection of materials, heat treatment, nonmetallic inclusions, and casting defects.

(No. of Lectures - 10)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Analysis of Metallurgical Failures, Colangelo, V.J., Heiser, F.A., John Wiley & Sons, Singapore.2012
2. Strength and Fracture of Engineering Solids, Felbeck, David K., Atkins, Anthony G., Prentice Hall, Inc., Englewood Cliffs.2008
3. Mechanical Metallurgy, Dieter, George E., Jr; McGraw Hill Book Co., New York. 2017
4. Failure Analysis- Case Histories and Methodology, Naumann, F.K., ASM, Metals Park, Ohio.2020
5. Failure and its Prevention, American Society for Metals, Metals Handbook, 8th Ed., Vol. 10, ASM, Metals Park, Ohio. 2001
6. Fundamentals of Fracture Mechanics, Knott, J.E., Butterworths,London.2003

ONLINE/E RESOURCES:

1. Engineering Fracture Mechanics (NPTEL course) by Prof. K. Ramesh, IITM.
2. Fracture, Fatigue and Failure (NPTEL course) by Prof. I. Sen, IIT Kharagpur

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DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT807	**Fatigue, Fracture and Creep**	**3**	**3**	**0**	**0**	**0**

PREREQUISITES: Mechanical behavior of Materials

COURSE OBJECTIVES:

- To develop an understanding of the fundamentals of fatigue, fracture and creep.
- To familiarized with the deformation aspect of engineering components.

COURSE OUTCOMES:

CO1	Understand fatigue, fracture and creep and their significance in materials design.
CO2	Evaluate critically the relevance of S- N curve, C- M plot, KIC, J- integral and LMP parameters.
CO3	Understand damage mechanisms under both cyclic and creep loading.

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following three components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I Introduction: Cyclic loading, stress- concentration, high cycle fatigue (HCF), Basquin equation, S- N curve, effect of stress ratio and mean stress on HCF damage, design against HCF, low cycle fatigue (LCF).

(No. of Lectures - 8)

Unit II Cyclic deformation mechanisms: C-M relationship, significance of C-M plot, cyclic hardening and softening mechanisms, cyclic stress- strain curve, fatigue damage mechanisms, Paris law of fatigue crack growth, fretting.

(No. of Lectures - 8)

Unit III Fundamental of fracture: Different modes of fracture, Griffith theory of fracture, stress- concentration factor, Linear elastic fracture mechanics (LEFM), concept of fracture toughness, KI_C, J Integral, factors influencing fracture toughness of engineering alloys.

(No. of Lectures - 12)

Unit IV Creep and related damage mechanisms: Creep of crystalline solids, role of temperature and stress on creep, Equi- cohesive temperature, creep and creep rate curves, Creep testing of engineering alloys, creep- deformation mechanisms, Nabarro- Herring and Coble creep, deformation mechanism maps, LMP parameter, Super plasticity.

(No. of Lectures - 12)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Mechanical Metallurgy, Dieter, George E., Jr; McGraw Hill Book Co., New York., 2017
2. Failure and its Prevention, American Society for Metals, Metals Handbook, 8th Ed., Vol. 10, ASM, Metals Park, Ohio,1998.
3. Fundamentals of Fracture Mechanics, Knott, J.E., Butterworths,London.,2002
4. The utilization of creep test data in engineering design, Bailey, R. W. Proceedings of the Institution of Mechanical Engineers, 1935.
5. Callister's Materials Science and Engienering, William D Callister, Wiley India (P) Ltd., 2007.

ONLINE/E RESOURCES

1. https://nptel.ac.in

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DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT803	**Defects and Diffusion in Crystalline solids**	**3**	**3**	**0**	**0**	**0**

PREREQUISITES: Mechanical behaviour of materials

COURSE OBJECTIVES:

- To familiarize with different types of defects, their interactions and their influence on properties.
- A survey of various means of characterizing (quantity and quality) defects

COURSE OUTCOMES:

CO1	Understand the properties of individual defects.
CO2	Understand about defect interactions.
CO3	Understand about defects in materials and their role in determining properties.

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following three components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I Basic Introduction: Origin and classification of defects, Basics of crystallography, crystal structures, crystal symmetry, thermodynamics and mechanics.

(No. of Lectures - 6)

Unit II Point Defects: Introduction, origin of point defects, Equilibrium Concentration, Point defects in metallic and ionic crystals and their interaction, Effects of point defect on properties with more emphasis on diffusion.

(No. of Lectures - 8)

Unit III Line Defects: Introduction, observation of dislocations, Burger vector, dislocation theory: atomistic, forces between dislocations, energy of dislocations, Jogs, dislocations in metallic and intermetallic systems, effects of dislocation on properties: focus on plasticity, Point- line defects interaction.

(No. of Lectures - 12)

Unit IV Planar Defects: Interface thermodynamics, interface structure, classification of interfaces, glissile / sessile interface, interface migration, grain boundaries and geometrical relationships, stacking faults, APBs, special boundaries, etc., effects of interfaces on mechanical and other properties.

(No. of Lectures - 10)

Unit V Characterization: Characterization tools used to identify the defects in the materials.

(No. of Lectures - 4)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Solid State Physics, C. Kittel, Intro to 3rd Ed., Wiley, 1968
2. Point Defects in Metals, C. Damask and G. J. Dienes; 1st ed., Gordon and Breach, 1963
3. Diffusion in Solids, P.G. Shewmon; 2nd ed., TMS, 1989
4. Introduction to dislocations, D. Hull and D. J. Bacon: 4th ed., Butterworth- Heinemann, 2001.
5. Interfaces in Crystalline Interfaces, P. Sutton and R. W. Balluffi; 1st ed., Oxford Univeristy Press, 1995
6. Mechanical Metallurgy, George E. Dieter: Mechanical Metallurgy, McGraw- Hill Book Company, 2017.

ONLINE/E RESOURCES:

1. Defects in crystalline solids (NPTEL course) by Prof. S Shekhar, IIT Kanpur

DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Scheme/Specialization: B.Tech. (Metallurgical and Materials Engineering)

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT827	**Introduction to Computational Materials Science**	**3**	**3**	**0**	**0**	**0**

PREREQUISITES: Introduction to Physical Metallurgy

COURSE OBJECTIVES:

- Introduce students to materials modeling and simulation techniques that cover a wide time and length scales.
- Show how these modeling methods can be used to understand fundamental material structure, material defects and the relationships between material structure and material behavior; and
- Develop an understanding of the assumptions and approximations that are involved in the modeling frameworks at the various time and length scales.

COURSE OUTCOMES:

CO1	Understand the basis for the simulation techniques, learn how to use computational modeling, and how to present and interpret the results of simulations
CO2	Understand theories and applications of atomistic scale modeling techniques to simulate, understand, and predict the properties of materials
CO3	Solve problems in materials science and engineering.

COURSE ASSESSMENT

The course assessment (culminating to the final grade), will be made up of the following three components

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I Introduction to materials modeling and simulation: Modelling and simulation, scales in materials structure and behavior, how to develop models.

(No. of Lectures - 4)

Unit II Basics: Random- walk model of diffusion, bulk diffusion, random walk simulation, random- walk model for materials. Simulation of finite systems: sum of interacting pairs, perfect crystals, cutoffs, periodic boundary condition, implementation, long- ranged potentials.

(No. of Lectures - 6)

Unit III Atoms and Molecules: Electronic structure methods, interatomic potentials, molecular dynamics, Monte Carlo method, molecular and macromolecular systems, Dislocation dynamics and Crystal plasticity.

(No. of Lectures - 10)

Unit IV Mesoscopic Methods: Kinetic Monte Carlo, Monte Carlo methods at mesoscale, cellular automata, phase-fields methods, mesoscale dynamics.

(No. of Lectures - 12)

Unit V Materials selection and design: Integrated computational materials engineering, concurrent material design, and material informatics.

(No. of Lectures - 8)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Introduction to Computational Materials Science; Richard Lesar, Material Research Society, Cambridge University Press, 2018.
2. Handbook of Materials Modelling, S. Yip, Springer, 2005.
3. Numerical Methods for Engineers, Santosh K. Gupta, New Age International (P) Limited, New Delhi, 1998.

ONLINE RESOURCE

1. www.cambridge.org/laser
2. https://nptel.ac.in

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DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING
MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR
Scheme/Specialization: B.Tech. (Metallurgical and Materials Engineering)

ENGINEERING MATERIALS

DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Scheme/Specialization: B.Tech. (Metallurgical and Materials Engineering)

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT310	**Composite Materials**	**3**	**3**	**0**	**0**	**0**

PREREQUISITE: Introduction to Engineering Materials

COURSE OBJECTIVE:

- Familiarize and equip the students with basic knowledge about composite materials

COURSE OUTCOMES:

CO1	Understand various basic concepts related to composite materials
CO2	Acquire ideas about the various types of composite materials
CO3	Understand role of each component of the composite materials
CO4	Identify various fabrication processes of composite materials
CO5	Understand how to reuse the composite materials after their service life is over

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following three components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I Introduction: Definition of composite materials. Advanced composites, Importance of composites over other materials. Advantages and general characteristics of composite materials, General requirements of composite materials.

(No. of Lectures - 5)

Unit II Matrix, Reinforcement, and Interface: Classification of composites on the basis of reinforcement and matrix, Form and functions of reinforcement, Functions of matrices. Dispersion strengthened, particle strengthened and fibre- reinforced composites. Strengthening mechanisms-discontinuous and continuous fibre composites. Comparison of above composites. Characteristics and materials of reinforcements and matrices. Testing for interfacial bond strength.

(No. of Lectures - 10)

Unit III Major composite classes: polymer matrix, metal matrix, ceramic matrix, carbon-carbon, and intermetallic composites, hybrid composites, laminated composites. Examples of each class of composites. Role of interfaces in composites, toughening mechanisms in PMCs, MMCs, and CMCs.

(No. of Lectures - 10)

Unit IV Micromechanics and fabrication methods: Micromechanics. Fabrication methods of PMCs, MMCs and CMCs, Reuse of composites after their service life.

(No. of Lectures - 10)

Unit V Recent Advances: Nanocomposites, challenges in the field of composites.

(No. of Lectures - 5)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Composite Materials: Properties, Non- destructive testing and Repair, Mel M. Schwartz, Prentice Hall, New Jersey, 1996
2. Composite Materials – Science & Engineering, K.K. Chawla., Springer- Veslag, New York, 3rd Ed, 2012
3. Industrial Materials: Polymers, Ceramics and Composites, David A. Colling & Thomas Vasilos, vol. 2, Prentice Hall, N. Jersey, 1995.
4. Composite Materials: Engineering and Science, F.L. Matthews and R. D. Rawlings, Chapman and Hall, London, 1994

ONLINE/E RESOURCES:

1. https://nptel.ac.in

DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING

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DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT821	**Automotive and Aerospace Materials**	**3**	**3**	**0**	**0**	**0**

PREREQUISITE: Introduction to Physical Metallurgy

COURSE OBJECTIVE:

Provide background on the various types of Materials used in the Automotive and Aerospace industries

COURSE OUTCOMES:

CO1	Familiarize various types of materials used in automotive and aerospace applications
CO2	Correlate the properties and applications of various lightweight materials used in the automotive and aerospace industries

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I Introduction: Introduction to applications of automotive materials, Aluminium alloys and Steel for automotive applications, High strength to weight ratio materials for chasis and body etc., Materials for piston and cylinder assembly, materials for transmission gears, shaft, cams and valves, materials for heavy duty springs, materials for different types of bearing, materials for radiator assembly

(No. of Lectures - 10)

Unit II Aerospace Materials: Aluminium alloys, Properties, Applications, Titanium alloys, Properties, Applications, High Strength Steels, Properties, Applications, Additive manufacturing for fabrication of Aerospace components**.**

(No. of Lectures - 10)

Unit III Composites: Introduction and Classification of Composites, Metal matrix composites, Polymer matrix composites, Fiber reinforcements, Basic Mechanics of Composites, Composites for aerospace applications: Fiber reinforced polymer and fiber

metal laminates (FML), Carbon fiber reinforced polymer (CFRP), Glass fiber reinforced polymer (GFRP), Materials for Aerospace components- propeller blades, turbine blades, space applications.

(No. of Lectures - 10)

Unit IV Superalloys: Introduction to Superalloys, Applications, Classification, Nickel based superalloys, Iron Based superalloys, Cobalt based superalloys, Different phases in superalloys.

(No. of Lectures - 10)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Physical Metallurgy of Steels, W.C. Laslie, McGraw Hill, 1981
2. Introduction to Physical Metallurgy, Sidney H. Avner, McGraw Hill, 2017
3. Fundamentals of Composite Materials, A.K. Shrivastava, Sankalp Publication, 2021
4. Composite Materials: Science and Engineering, Krishan K. Chawla, Springer, 2012
5. Light Alloys: Metallurgy of the Light Metals, I J Polmear, Butterworth- Heinemann, 2017
6. The Superalloys: Fundamentals and Applications, Roger C. Reed, Cambridge University Press, 2008

ONLINE RESOURCES:

1. https://nptel.ac.in

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DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT829	**Properties and Processing of Polymers**	**3**	**3**	**0**	**0**	**0**

PREREQUISITES: Basic Knowledge of Physics and Chemistry and basics of engineering materials

COURSE OBJECTIVE:

- Acquire the knowledge about structures, properties, processing and applications of engineering polymers.

COURSE OUTCOMES:

CO1	Understand different types of polymers.
CO2	Correlate the structure, properties and applications of polymers.

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following three components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I Introduction to Polymers: Thermoplastics, Thermosets, High- Performance Polymers, Liquid crystal polymers, Polymer blends & alloys, Shape memory polymers, Thermoplastic Elastomers, Thermoset Elastomers, Molecular Weight Distributions, roles of additives, Glass transition temperature.

(No. of Lectures - 8)

Unit II Factors Affecting Properties: Effect of chemical composition, types of bonds and structures on mechanical, thermal, electrical, barrier and rheological properties of polymers. Effect of molecular weight, cross linking, filler, and additives on transitions temperatures.

(No. of Lectures - 8)

Unit III Processing Techniques: Injection Molding**,** Special Injection Molding Processes (multi- component Injection Molding, Co- Injection Molding, Gas- Assisted Injection Molding, Injection- Compression Molding, Reaction Injection Molding, Liquid Silicone Rubber Injection Molding), Extrusion, Blow Molding, Rotational Molding, Thermoforming, Calendering, Foaming.

(No. of Lectures - 8)

Unit IV Additive Manufacturing Techniques: Stereo lithography, fused filament fabrication, Selective laser sintering, other 3D printing techniques etc.

(No. of Lectures - 8)

Unit V Applications: Applications of polymers, blends and their composites/ nanocomposites/hybrids for structural, tribology, electronics, aerospace, biomedical field etc.

(No. of Lectures - 8)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Introduction to Plastics Engineering, Vijay K. Stokes, John Wiley & Sons Ltd, UK, 2020.
2. Plastics Engineering, 4th Edition, R. J Crawford and P. J Martin. Elsevier, UK. 2020.
3. Material Science of Polymers for Engineers, 3rd Edition, Tim A. Oswald and Georg Menges., Hanser Publications, Cincinnati, USA, 2012.

ONLINE RESOURCES

1. https://nptel.ac.in

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DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT830	**Tribological Engineering Materials**	**3**	**3**	**0**	**0**	**0**

PREREQUISITES: Basic knowledge in material science and engineering

COURSE OBJECTIVES:

- Provide knowledge on the tribology in material science and engineering
- Provide the knowledge on the importance of material design in tribology

COURSE OUTCOMES:

CO1	Understand the scientific and engineering principles underlying tribology of engineering materials
CO2	Apply and integrate knowledge of material structure and property on the design of materials suitable for tribological applications
CO3	Understand the engineering principles of surface treatment and lubricants in tribology

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following three components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I: Introduction to tribological processes and tribologically relevant properties of materials, friction materials and their application. Antifriction/conventional bearing materials, wear resistant materials. An overview of engineering materials having potential for tribological application.

(No. of Lectures - 8)

Unit II: Characterization of Ferrous and non-Ferrous materials for tribological requirements/applications. Surface treatment techniques with applications such as carburizing, nitriding, induction hardening, hard facing and laser surface treatments.

(No. of Lectures - 8)

Unit III: Surface coating techniques such as electrochemical depositions, anodizing, thermal spraying, Chemical vapour deposition.

(No. of Lectures - 7)

Unit IV: Materials for specific applications e.g. seals, hydraulic components and high temperature & low temperature (freezing conditions) applications. Evolution and characteristics of Nano-materials, functionally graded materials and nanocomposites for tribological applications.

(No. of Lectures - 8)

Unit V: Lubricants and lubrication types: types and properties, additives and their role; Grease, solid lubricants. Standards, evaluation, testing and selection of lubricants. Hydrodynamic Lubrication - Elasto hydrodynamic lubrication, Boundary Lubrication - Solid Lubrication Hydrostatic Lubrication Salvaging and re-use of lubricants. Critical environmental problems related to use of lubricants and possible control measures.

(No. of Lectures - 9)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Engineering Tribology, G.W. Stachowiak, A. W. Batchelor, Butterworth- Heinemann Ltd; 2nd edition, 2000.
2. Handbook of Micro/Nano Tribology (Mechanics and Materials Science Series) 2nd Edition, by Bharat Bushan (Editor)CRC Press; 2nd edition, 2020.
3. Principles of Tribology, Shizhu Wen, Ping Huang, Wiley, November 2011.
4. Tribology Friction and Wear of Engineering Materials, Ian Hutchings and Philip Shipway, Elsevier Science, 2017.

ONLINE RESOURCES

1. https://nptel.ac.in

DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING

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Scheme/Specialization: B.Tech. (Metallurgical and Materials Engineering)

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT820	**Advanced Solar Photovoltaic Materials and Technologies**	**3**	**3**	**0**	**0**	**0**

PREREQUISITE: Engineering Materials

COURSE OBJECTIVE:

- To familiarize and equip the students with basic knowledge about different types 3rd generation solar cells

COURSE OUTCOMES:

CO1	Understand various basic aspects of solar photovoltaic technology
CO2	Acquire ideas about the solar cells characterizations
CO3	Understand constructional and working principles of different types of 3rd generation solar cells

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following three components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I Introduction: Review and basics of Semiconductor physics, Metallurgy of silicon, Production of metallurgical and electronic grade Si, Principle of solar energy conversion, Device Physics of Solar Cells.

(No. of Lectures - 8)

Unit II Basics: Solar irradiation measurements, Evaluation of solar cells, Solar cell modules, Electrical and optical losses, Introduction to 1st and 2nd generations of solar cells and their advantages and limitations, Potential and drawbacks of current manufacturing technologies, Economic aspects, Introduction to 3rd generation solar cells.

(No. of Lectures - 10)

Unit III Organic solar cells: Fundamentals of organic semiconductors (Bonding, Conjugation, Hybridization, Electronic structure), Introduction to Organic solar cells, various

device architectures, Physics of Bulk Hetero-junction (BHJ) solar cells, Morphology and charge separation in BHJ.

(No. of Lectures - 7)

Unit IV Dye- sensitized solar cells: Introduction to Dye- sensitized solar cells (DSSCs), Fabrication of DSSCs, Design and selection of novel dyes and solid electrolytes materials, Counter electrode engineering.

(No. of Lectures - 7)

Unit V Perovskite solar cells and Recent Advances: Introduction, Fabrication of perovskite solar cells, Photo physics in perovskite solar cells, Stability in perovskite solar cells, Lead- free perovskite solar cells, Multiple exciton generation and Quantum dot solar cells.

(No. of Lectures - 8)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Solar Photovoltaics: Fundamentals, Technologies and Applications, Chetan Singh Solanki, PHI Publications, 3rd Edition, 2015
2. Solar Energy, S.P. Sukhatme, Tata McGraw Hill, 2008
3. Solar Cell Device Physics, Stephen Fonash, Elsevier, 2nd Edition, 2009

ONLINE/E RESOURCES/ Suggested Readings:

1. https://nptel.ac.in
2. Semiconductor Devices: Basic Principles, J. Singh, Wiley, 2000
3. Organic Electronics: Materials, Processing, Devices and Applications, CRC Press, 2009

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DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT823	**Ceramics and Glasses**	**3**	**3**	**0**	**0**	**0**

PREREQUISITES: Introduction to Engineering Materials

COURSE OBJECTIVES:

Provide the basic knowledge of the processing and design of ceramic materials, glass, glass-ceramic materials, and binders in terms of both science and engineering

COURSE OUTCOMES:

CO1	Identify technically important ceramic and glass materials.
CO2	Understand the basics of the properties of ceramic and glass materials.
CO3	Infer a material with the required properties using characterization techniques.

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following three components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I Ceramics: Definition and scope of ceramics and ceramic materials, classification of ceramic materials, areas of applications, bonding and structure of various ceramic materials, crystal structure and defects, polymorphic transformations, raw materials, and defects in ceramics.

(No. of Lectures - 6)

Unit II Glass: Definition, glass structure, difference between glass and crystalline materials, types and composition of glass, fundamentals of glass formation, Zachariasen rules, viscosity-based transition points, de-vitrification, glass forming methods, major glass industries in India and the world, market scenario of the glass industry.

(No. of Lectures - 7)

Unit III Glass-Ceramics: Definition, production of glass- ceramics, application of glass ceramics, types of glass ceramics, photosensitive lithium aluminum silicate, magnesium aluminum silicate, machinable glass ceramics, bio- active glass ceramics, sintered glass ceramics, nanoceramics, electronic ceramics, electro- optic ceramics, magnetic ceramics, ceramic superconductors.

(No. of Lectures - 8)

Unit IV Processing: Powder processing, pre- consolidation, shape forming processes, fundamental sintering mechanisms, and various advanced sintering techniques.

(No. of Lectures - 6)

Unit V Properties: Electrical conductivity, dielectric properties, magnetic properties, optical properties, thermal properties, and mechanical properties, emphasis on the effects of composition, microstructure, processing, temperature and atmosphere on these properties.

(No. of Lectures - 6)

Unit VI Testing of Ceramics and Glasses: Porosity testing, creep and rupture testing, cryogenic testing, electrical testing, high temp performance testing, mechanical testing, metallurgical evaluation, microbiology testing, microstructural analysis, mineralogical analysis, refractory materials testing, surface analysis.

(No. of Lectures - 7)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Fundamentals of ceramics, M. W. Barsoum, 2nd edition, CRC Press, 2020.
2. Ceramic Processing, M. N. Rahaman, 2nd edition, CRC Press, 2017.
3. Materials Characterization Techniques, S. Zhang, L. Li and A. Kumar, CRC Press, 2008.
4. Introduction to Ceramics, 2nd edition, W. David Kingery, H. K. Bowen, Donald R. Uhlmann, Wiley, 1976.

ONLINE/E RESOURCES

1. https://nptel.ac.in/
2. www.lucideon.com

DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING

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Scheme/Specialization: B.Tech. (Metallurgical and Materials Engineering)

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT822	**Biomaterials**	**3**	**3**	**0**	**0**	**0**

PREREQUISITES: Basic Sciences

COURSE OBJECTIVES:

- Learn characteristics and classification of Biomaterials
- Understand different metals, ceramics and its nanomaterials characteristics as biomaterials
- Learn polymeric materials and its combinations that could be used as a tissue replacement implants
- Get familiarized with the concepts of Nano Science and Technology
- Understand the concept of biocompatibility and the methods for biomaterials testing

COURSE OUTCOMES:

CO1	Understand common use of biomaterials as metals, ceramics and polymers and its chemical structure, properties, and morphology.
CO2	Identify significant gap required to overcome challenges and further development in metallic and ceramic materials, polymeric materials
CO3	Create combinations of materials that could be used to replace different organs & tissues of human body.
CO4	Understand the testing standards applied for biomaterials.

COURSE ASSESSMENT:

The Course assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Weekly submissions/ assignments/ quizzes	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I Introduction to Biomaterials: Introduction, historical developments, impact of biomaterials, biological tissue, implants, safety and efficacy testing. Bulk properties and surface properties of materials, characterization methods of surface properties of Biomaterials.

(No. of Lectures - 6)

Unit II Metallic and Ceramic Materials: Metallic implants – stainless steels, Co- based alloys, Ti- based alloys, shape memory alloy, nanostructure metallic implants, degradation

and corrosion, Ceramics – carbons, alumina, yttria based zirconia, resorbable ceramics, bioactive ceramics, nanostructured bio ceramics.

(No. of Lectures - 12)

Unit III Polymeric Materials: polymers as biomaterials, biodegradable polymers, Bio polymers: collagen, elastin and chitin. Soft tissue application, medical textiles, materials for ophthalmology: contact lens, intraocular lens. Membranes for plasma separation and blood oxygenation. Biological functional materials, grafts and other materials.

(No. of Lectures - 10)

Unit IV Testing of Biomaterials: Biocompatibility, blood compatibility and tissue compatibility tests, Toxicity tests, sensitization, carcinogenicity, mutagenicity and special tests, Invitro and Invivo testing; sterilisation of implants and devices: ETO, gamma radiation, autoclaving, effects of sterilization.

(No. of lectures - 6)

Unit V Application of Biomaterials: Cardiovascular Applications; Dental implants; Adhesives and Sealants; Ophthalmologic Applications; Orthopedic Applications; Drug Delivery System; Sutures; Bioelectrodes; Biomedical Sensors and Biosensors. Materials used In Medicine: Metals; Polymers; Hydrogels, Bioresorbable and Biodegradable Materials.

(No. of Lectures - 6)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Biomaterials, Second Edition, Sujata V. Bhatt, Narosa Publishing House, 2005.
2. Functional Materials: Electrical, Dielectric, Electromagnetic, Optical and applications, Deborah D. L. Chung, World Scientific Pub., Vol. 2, 2010.
3. Functional Materials: Preparation, Processing and Applications, S Banerjee and A. K. Tyagi, 1st Edition, Elsevier, USA, 2012.
4. Biomaterials Science: An Introduction to Materials in Medicine, Schoen, F. J., Ratner, B. D., Hoffman, A. S., Lemons, J. E, Netherlands: Elsevier Science, 2004.
5. Biomaterials: an interfacial approach; Hench, LL, Ethridge, EC, Academic Press, 1982.
6. The Biomedical Engineering Handbook, Bronzino, J.D., CRC Press, Germany, 2000.

ONLINE/E RESOURCES

1. https://nptel.ac.in

DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING

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Scheme/Specialization: B.Tech. (Metallurgical and Materials Engineering)

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT812	**Nuclear Materials**	**3**	**3**	**0**	**0**	**0**

PREREQUISITES: Mineral Processing, Introduction to Extractive Metallurgy

COURSE OBJECTIVES:

- To provide enough background in nuclear materials and their properties, applications and safety precautions.
- To gain a working knowledge of the extraction of nuclear materials from their ores.

COURSE OUTCOMES:

CO1	Understand about different types of materials used in nuclear reactors.
CO2	Understand the extraction process of nuclear materials.
CO3	Correlate the properties of nuclear materials and their applications.

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following three components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I Introduction: Brief outlines of essential requirements of metals for nuclear energy programs - Structural, fissile, moderator and control, materials for canning, control rods, moderators, coolants, pressure vessels, heat exchanging tubing, and shielding, materials selection, types of reactors, nuclear fission and fusion, radioactive fuel, Indian reactors, and atomic energy programs.

(No. of Lectures - 12)

Unit II Extraction of Nuclear Fuels: Introduction, metallic fuels – Uranium, Plutonium, Thorium; Minerals and their occurrence in India, extraction of nuclear fuels, properties, applications, brief introduction of ceramic fuels.

(No. of Lectures - 15)

Unit III Extraction of Zirconium and Hafnium: Minerals and their occurrence in India, preparation of zirconium oxide and hafnium oxide, Kroll process, bimetal reduction, properties, application, Van-Arkel process.

(No. of Lectures - 5)

Unit IV Extraction of Beryllium: Minerals and their occurrence in India, purification, properties, applications.

(No. of Lectures - 5)

Unit V Safety Measurements: Radioactive wastage, hazardous, and preventions.

(No. of Lectures - 3)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Extraction and Metallurgy of Uranium, Thorium and Beryllium, RG & Hill, NA Bellamy, Pergamon Press, 1963.
2. Uranium Production Technology, C. D. Harigton & A.D. Ruchle, Van Nostrand Publication. Krieger Publishing Company; First Edition, 1959.
3. Extraction of Nuclear and Non- ferrous Metals, S. K. Dutta and D. R. Lodhari, Springer, 2018.

ONLINE/E RESOURCES:

1. https://nptel.ac.in

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MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Scheme/Specialization: B.Tech. (Metallurgical and Materials Engineering)

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT824	**Design and selection of materials**	**3**	**3**	**0**	**0**	**0**

PREREQUISITE: Engineering materials, Mechanical behavior and testing.

COURSE OBJECTIVE:

- The subject exposes students to the basic parameters for selection of materials and different classes of materials, manufacturing processes and their properties, applications of materials.

COURSE OUTCOMES:

CO1	Understand the importance of materials selection.
CO2	Describe the process flow of manufacturing process.
CO3	Distinguish different design criteria for manufacturing process.
CO4	Describe the case study on design.
CO5	Sketch different failure criteria for safe design of components.

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I Material Selection in Design: General criteria for material selection, performance characteristics of materials, materials selection process, design process and materials selection, economics of materials, recycling and materials selection.

(No. of Lectures - 4)

Unit II Materials Properties and Design: Role of crystal structure. Stress – Strain diagram, design for strength, rigidity. Effect of static strength, stiffness, fracture toughness. Design for yielding and fracture toughness, fatigue, creep and wear resistance, brittle fracture, corrosion resistance. Designing with plastics, brittle materials.

(No. of Lectures - 10)

Unit III Manufacturing Considerations in Design: Surface finish, texture and dimensional tolerances in fitting, interchangeability, selective assembly and geometric tolerance. Selection of fits and tolerances.

(No. of Lectures - 4)

Unit IV Types of design, Design Tools and Materials Data: Design under static loading, variable loading, eccentric loading, stress concentration. Design examples with shaft design, spring design and C- frames, Materials and shape – microscopic and microstructural shape factors – limit to shape efficiency. Comparison of structural sections and materials indices – case studies.

(No. of Lectures - 8)

Unit V Materials Selection: Ashby Method, Case Studies, Multiple Constraints in materials selection, Multiple Objectives, Role of Materials in Shaping the Product Character.

(No. of Lectures - 4)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Engineering Design: A materials and processing approach, G.E. Dieter, 4th Edition, McGraw Hill, 2008.
2. Design of Machine Elements, V.B. Bhandari, 4th Edition, Tata McGraw- Hill Education, 2017.
3. Materials Science and Engineering: An Introduction, W.D. Callister, D.G. Rethwisch, 9th edition, John Wiley, 2013.
4. Engineering Materials: Properties and Selection, K. Budinski, M. Budinski, 9th edition, PHI Learning Private Limited, 2009.
5. Materials Selection and Design, M.A. Maleque, M.S. Salit, Springer, 2013.
6. Materials Selection in Mechanical Design, M. F. Ashby, Elsevier Science, 2016.

ONLINE/E RESOURCES:

1. https://nptel.ac.in

DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING

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DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT825	**Electronic and Magnetic Materials**	**3**	**3**	**0**	**0**	**0**

PREREQUISITES: Introduction to Engineering Materials

COURSE OBJECTIVES:

- To provide a fundamental understanding of the electronic and magnetic properties of materials and to use that understanding in the selection and development of materials for various engineering applications.

COURSE OUTCOMES:

CO1	Understand electronic and magnetic materials.
CO2	Apply the knowledge in manufacturing the ICs based on lithography.
CO3	Describe the magnetic properties of materials.

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following three components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I Electronic Materials: Review of electronic materials, types of electronic materials, application, intrinsic semiconductors, electron and hole concentrations, Fermi energy level, effect of temperature on Fermi energy, carrier mobility, direct vs. indirect band gap materials, elemental vs. compound semiconductors, extrinsic semiconductors, doping – p and n- type semiconductors, carrier concentration and Fermi level as a function of temperature, drift mobility, light and heavy doping.

(No. of Lectures - 9)

Unit II Manufacturing Process of the electronic materials and Wafer Technology: Crystal growth methods for bulk single crystals - zone melting- refining, leveling - synthesis of epitaxial films by VPE, PVD, MBE and MOCVD techniques, semiconductor materials, lithography – wafer technology, basic patterning and surface preparation to exposure, photo masking, photo resist and their performance factors, etching, dry and wet etching, resistor stripping, production of silicon - starting applications, antireflective coatings.

(No. of Lectures - 9)

Unit III Specific Electronic Materials: LEDs and solar cell materials, transistors – MOSFETs, band diagram and channel formation, threshold voltage, I- V characteristics.

(No. of Lectures - 6)

Unit IV Magnetic Materials: History of magnetism and magnetic materials, magnetic Unit s, concepts and terminology, classification of magnetic materials, magnetic domains and domain structure, magnetic hysteresis, magnetic anisotropy and magnetostriction, theories of diamagnetism, paramagnetism, theories of ordered magnetism, hard and soft magnetic materials.

(No. of Lectures - 9)

Unit V Specific Magnetic Materials: Magneto- resistive materials, magneto- electric materials, magneto- elastic materials, materials with shape memory, materials for magnetic recording, magnetic refrigerant materials, magnetic materials in electric vehicles and hyper loop trains.

(No. of Lectures - 7)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Magnetism and Magnetic Materials, J. M. D. Coey, Cambridge University Press, 2010.
2. Introduction to Magnetic Materials, B. D. Cullity and C. D. Graham, NY: Wiley- IEEE Press, 2008.
3. Principles of Electronic Materials and Devices, S. O. Kasap, McGraw Hill Education, 2017
4. Semiconductor Materials, Devices and Fabrication, Parasuraman Swaminathan, Wiley 2017

ONLINE/E RESOURCES:

1. https://nptel.ac.in

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DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MTT819	**Advanced Microscopic Techniques**	**3**	**3**	**0**	**0**	**0**

PREREQUISITE: Material characterization techniques

COURSE OBJECTIVE:

- To provide background and details of the various advanced microscopic techniques used in materials and metallurgical research.

COURSE OUTCOMES:

CO1	Understand the working principles of the various microscopic techniques
CO2	Analyse the output from the techniques and correlate with the structure of materials

COURSE ASSESSMENT:

The course assessment (culminating to the final grade), will be made up of the following components.

S. No.	Component	Weightage
a)	Weekly submissions/assignments/Quiz	20%
b)	Mid- term examination	40%
c)	End Semester Examination	40%

COURSE CONTENTS:

Unit I Light Optical Microscopy: Polarization microscopy, Phase contrast microscopy, DIC Microscopy and confocal microscopy, Resolution, Magnification

(No. of Lectures - 6)

Unit II Diffraction Techniques: X- Ray Diffraction, Electron Diffraction, Ewald Sphere, Reciprocal space, Stereographic Projections

(No. of Lectures - 8)

Unit III Electron Microscopy: Scanning electron microscopy (SEM), Energy dispersive X-ray spectroscopy (EDS), Wavelength dispersive X- ray spectroscopy (WDS), Electron Back Scatter Diffraction (EBSD), Transmission electron microscopy (TEM)

(No. of Lectures - 12)

Unit IV Scanning Probe Microscopy: Scanning tunneling microscopy (STM) & atomic force microscopy (AFM)

(No. of Lectures - 6)

Unit V Spectroscopic Characterization: X- ray photoelectron spectroscopy (XPS), X- ray fluorescence (XRF), Fourier- transform infrared spectroscopy (FTIR) and Raman spectroscopy

(No. of Lectures - 8)

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):

1. Electron Microscopy and Analysis, Peter J Goodhew, John Humphreys, Richard Beanland, Taylor and Francis, 2000
2. Microstructural Characterization of Materials, David Brandon and Wayne D. Kaplan, Wiley, 2008
3. Scanning Electron Microscopy and X- ray Microanalysis, Joseph I Goldstein, Springer, 2003
4. Crystallographic Texture of Materials, Satyam Suwas, R K Ray, Springer, 2016

ONLINE RESOURCES

1. https://nptel.ac.in