Course Scheme

(2024 Onwards)

Department of

Metallurgical and Materials Engineering

Credits structure for

B.Tech. METALLURGICAL & MATERIALS ENGINEERING Programme (2024 onwards)

CURRICULAR COMPONENTS	Credits
(A) Institute Core Course (ICC) a) Basic Science (BSC) b) Engineering Science (ESC) c) General Science (GSN)	 16 20 02
Total	**38**
(B) Humanities, Communication and Management Elective Courses (HSSMEC)	12
(C) Department Core Courses (DCC)	56
(D) Departmental Elective Courses (DEC)	16
(E) Institute Open Elective Courses (OEC)	11
(F) Projects (Minor/Major Project-I & II)	12
(G) Internship/Course Work* (4 credits of Dept.. Elective+4 credits of Open Elective+4 credits of Project work) * **Optional**	12
(H) Non-Academic (NAC)	4
Grand Total (For those who **do no opt** for Honors/Minor Specialization)*	161
(I) Honors/Minor Specialization	12/18
Grand Total (For those who **opt** for degree with Honors/Minor Specialization)	161+12/18

Semester wise UG Scheme applicable to UG students admitted in the 2024 onwards

S.No.	SEMESTER-I	Credits
1	Orientation	1
2	Introduction to Discipline Engineering	1
	SEMESTER-I (Pool A/Pool B)	
3	BSC-1 (Mathematics)	4
4	BSC-II (Physics)/BSC-IV (Chemistry)	4
5	Environmental Science/Universal Human Values	1
6	ESC-I/ESC-II***	4
7	HSM-I/ESC-III & ESC-VII***	3/2&2
8	ESC-V (or ESC-VI)/ESC-IV	4
	TOTAL	**22/23**

SEMESTER – II (Pool A/Pool B)		
S.No.		**Credits**
1	BSC-III (Mathematics)	4
2	BSC-IV (Chemistry)/BSC-II (Physics)	4
3	Universal Human Values/Environmental Science	1
4	ESC-II/ESC-I***	4
5	ESC-III & ESC-VII***/HSM-I	2&2/3
6	ESC-IV/ESC-V (or ESC-VI)	4
	TOTAL	**21/20**

SEMESTER-III (CB/NCB)		
S.No.		**Credits**
1	***EVC by Wadhwani Foundation (HSM-II)*** /Deptt Core Courses (DCC)	3/4
2	Dept. Core Courses (DCC)	16
3	***OE-1 (MOOCs course)***	**3**
	TOTAL	**22/23**

SEMESTER-IV (CB/NCB)		
S.No.		**Credits**
1	Dept. Core Courses (DCC)/ ***EVC by Wadhwani Foundation (HSM-II)***	4/3
2	Dept. Core Courses (DCC)	20
	TOTAL	**24/23**

SEMESTER-V		
S.No.		**Credits**
1	Dept. Core Courses (DCC)	16
2	Minor Project	4
	TOTAL	**20**

SEMESTER-VI (CB/NCB)		
S.No.		**Credits**
1	HSM-III/HSM-IV	3
2	DEC-I	4
3	DEC-II	4
4	OE-II	4
5	Major Project-I	4
	TOTAL	**19**

SEMESTER-VII (CB/NCB)		
S.No.		**Credits**
1	HSM-IV/HSM-III	3
2	DEC-III	4
3	DEC-IV	4
4	OE-III	4
5	Proficiency	2
6	Major Project-II*	4
	TOTAL	**21**

SEMESTER-VIII		
S.No.		**Credits**
1	**Internship Training (Optional)**	12
	Students opting for course work will do Deptt. Elective (4 credits), Open Elective (4 credits) and Project Work (4 credits)	
	TOTAL	**12**

ABBREVIATIONS	
Basic Science Course	BSC
Engineering Science Course	ESC
Humanities, Social Sciences & Mgmt.	HSM
Circuital Branches	CB

ABBREVATIONS	
Department Core Course	DCC
Department Elective Course	DEC
Open Elective Course	OE
Non-Circuital Branches	NCB

Total Credits=161 without Honors/Minor Specialization

Honors Degree

Semester		Credits
V	Honours Project-I	3
VI	Honours Project-II*	4
VII	Honours Project-III**	5
	TOTAL	**12**

Minor Specialization

Semester		Credits
III	Minor Specialization Course-I	4
IV	Minor Specialization Course-II	4
V	Minor Specialization Course-III	4
VI	Minor Specialization Project-I	3
VII	Minor Specialization Project-II*	3
	TOTAL	**18**

Total =161+12/18 with Honors/Minor Specialization

* It is proposed that 'A+' grade should only be given to students who have at least one paper accepted/published in refereed Journal or full length papers published in peer reviewed conferences organized by IISC/IIT/NIT/IIIT/Premier R&D organizations/ Professional societies or any patent published or first 3 position holders in any reputed national hackathons or project competitions or participation in International hackathons or project competitions.

** It is proposed that 'A+' grade should only be given to students who have at least one paper accepted/published in SCI/SCIE/SSCI/Web of Science/SCOPUS Indexed Journals or any patent published or first 3 position holders in any reputed national hackathons or project competitions or participation in International hackathons or project competitions.

*** The following ESC courses are proposed to be mandatory for all branches: -

i. Introduction to Computer Programming (ESC-I)
ii. Engineering Drawing with CAD software (ESC-II)
iii Skill Development Workshop (IoT& Sensor/Drone Technology etc.) (ESC-III)
iv. Introduction to Mechatronics (ESC-IV)
v. Introduction to Product Design (ESC-VII)

HONOURS/MINOR SPECIALIZATION PROGRAMME

Students with good academic performance (having CGPA ≥ 8.5 for Honours and CGPA ≥ 7 for Minor specialization) and desirous of excelling further in academics have the following opportunities:

a) **Honours:** To get Honours in the parent discipline, a student will have to earn additional 12 credits (over and above 161 credits) in the parent department.

b) **Minor Specialization:** To get Minor specialization, a student will have to complete 18 credits (over and above 161 credits) by doing courses outside the parent department during the entire duration of the programme in the institute.

Honours/ Minor specialization will be awarded to a student on the recommendation of the DAPC of the parent department. A student may do Honours, Honours with Minor Specialization OR Minor Specialization only.

Semester Scheme B.Tech. 1st Year

POOL – B

Aerospace Engineering – 30	Computer Science and Engineering (Artificial Intelligence) – 30
Mechanical Engineering – 120	Mathematics and Computing – 30
Electronics and Communication Engineering – 120	Electronics Engineering (VLSI Design and Technology) – 30
Metallurgical and Materials Engineering - 60	

Semester-I

Course ID	Course Name	L	T	P	Credits
OR 2301	Orientation	**-**	**-**	**-**	**1**
OR 2302	Introduction to Discipline Engineering	**1**	**0**	**0**	**1**
MA 2301	Calculus	**3**	**0**	**2**	**4**
CH 2302	Applied Chemistry	**3**	**0**	**2**	**4**
GS 2302	Universal Human Values	**1**	**0**	**0**	**1**
ES 2302	Engineering Drawing with CAD Software	**2**	**0**	**4**	**4**
ES 2303	Skill Development Workshop	**0**	**0**	**4**	**2**
ES 2307	Introduction to Product Design	**0**	**0**	**4**	**2**
ES 2304	Introduction to Mechatronics	**3**	**0**	**2**	**4**
	Total				**23**

Semester-II

Course ID	Course Name	L	T	P	Credits
MA 2302	Linear Algebra, Differential Equations and Vector Calculus	**3**	**0**	**2**	**4**
PY 2303	Condensed Matter Physics	**3**	**0**	**2**	**4**
ES 2301	Introduction to Computer Programming	**3**	**0**	**2**	**4**
GS 2301	Introduction to Environmental Sciences	**1**	**0**	**0**	**1**
HS 2351	Communication Skills	**2**	**0**	**2**	**3**
ES 2306	Strength of Materials	**3**	**0**	**2**	**4**
	Total				**20**

SEMESTER SCHEME B.TECH. 3RD TO 8TH SEMESTER 2024 ONWARDS

Semester-III

Course ID	Course Name	L	T	P	Credits
MMN 301	Special Materials & their Applications: DCC - I	**3**	**1**	**0**	**4**
MMN 302	Physical Metallurgy: DCC - II	**3**	**0**	**2**	**4**
MMN 303	Extractive Metallurgy of Non-Ferrous Metals: DCC - III	**3**	**1**	**0**	**4**
MMN 304	Metallurgical Thermodynamics and Kinetics: DCC - IV	**3**	**1**	**0**	**4**
MMN 305	Electric Vehicle Materials: DCC - V	**3**	**1**	**0**	**4**
SMOOCS	OE-I (MOOCs course)	**3**	**0**	**0**	**3**
	Total				**23**

Semester-IV

Course ID	Course Name	L	T	P	Credits
MHN 205	EVC by Wadhwani Foundation-HSM-II	**2**	**1**	**0**	**3**
MMN 401	Mechanical Behaviour of Materials DCC - VI	**3**	**1**	**0**	**4**
MMN 402	Iron Making Technology: DCC - VII	**3**	**1**	**0**	**4**
MMN 403	Phase Transformations & Heat treatment: DCC - VIII	**3**	**0**	**2**	**4**
MMN 404	Corrosion and its Control: DCC - IX	**3**	**1**	**0**	**4**
MMN 405	Metal Casting Technology: DCC - X	**3**	**0**	**2**	**4**
	Total				**23**

Semester-V

Course ID	Course Name	L	T	P	Credits
MMN 501	Steel Making Technology: DCC - XI	**3**	**0**	**2**	**4**
MMN 502	Advanced Materials Processing: DCC - XII	**3**	**1**	**0**	**4**
MMN 503	Welding Technology: DCC - XIII	**3**	**1**	**0**	**4**
MMN 504	Materials Characterization & Testing: DCC - XIV	**3**	**0**	**2**	**4**
MMP 510	Minor Project	**0**	**0**	**8**	**4**
	Total				**20**

Semester-VI

Course ID	Course Name	L	T	P	Credits
	HSM-III/HSM-IV	**3**	**0**	**0**	**3**
MME 105/107/108	Dept. Elective Course-I	**3**	**1**	**0**	**4**
MME 106/109/110	Dept. Elective Course-II	**3**	**1**	**0**	**4**
MMO 102	Open Elective-II	**3**	**0**	**2**	**4**
MMO 103/104/105		**3**	**1**	**0**	
MMP 701	Major Project-I	**0**	**0**	**8**	**4**
	Total				**19**

Dept. Elective course I
1. Polymers for Industrial Applications (MME 105)
2. Nanomaterials: Recent Developments and New Directions (MME 107)
3. Ceramics and their Advanced Applications (MME 108)

Dept. Elective course II
1. Surface Engineering (MME 106)
2. Light Alloys and Composite Materials (MME 109)
3. Non-Conventional Energy: Harvesting and Storage (MME 110)

Open Elective II
1. Advanced Materials Characterization (MMO 102)
2. Nanomaterials Technology and Applications (MMO 103)
3. Materials for E-Mobility (MMO 104)
4. Light Metals and Composites (MMO 105)

Semester-VII					
Course ID	**Course Name**	**L**	**T**	**P**	**Credits**
	HSM-IV/HSM-III	**3**	**0**	**0**	**3**
MME 101/102	Dept. Elective Course-III	**3**	**1**	**0**	**4**
MME 111/112/113	Dept. Elective Course-IV	**3**	**0**	**2**	**4**
MMO 107/108	Open Elective-III	**3**	**1**	**0**	**4**
MMO 109	Proficiency	**2**	**0**	**0**	**2**
MMP 801	Major Project-II*	**0**	**0**	**8**	**4**
	Total				**21**

Dept. Elective course III

1. Transport Phenomena (MME 101)
2. Extractive Metallurgy: Rare Earth Metals (MME 102)

Dept. Elective course IV

1. Modelling and Simulation in Materials (MME 111)
2. Advanced Materials Characterization (MME 112)
3. Failure Analysis of Metals and Alloys (MME 113)

Open Elective III

1. Corrosion Engineering (MMO 107)
2. Failure Analysis of Materials (MMO 108)

Semester-VIII					
Course ID	**Course Name**	**L**	**T**	**P**	**Credits**
MMN 601,602, 603	Internship Training				6+3+3=**12**
	OR				
MME 103/104	Dept. Elective course V	**3**	**1**	**0**	**4**
MMO 101	Open Elective Course	**3**	**0**	**2**	**4**
MMO 106		**3**	**1**	**0**	
MMP 601	Project work	**0**	**0**	**8**	**4**
	Total				**12**

Dept. Elective course V

1. Plasma Technology (MME 103)
2. High Entropy Alloys (MME 104)

Open Elective Course

1. Failure Analysis of Metals and Alloys (MMO 101)
2. Advanced Materials Processing (MMO 106)

Honors

Course ID	**Semester**	**Course Name**	**L**	**T**	**P**	**Credits**
MMH 101	V	Honors Project-I	0	0	6	3
MMH 102	VI	Honors Project-II*	0	0	8	4
MMH 103	VII	Honors Project- III**	0	0	10	5
	Total					**12**

Minor Specialization in Materials Engineering

Course ID	**Semester**	**Course Name**	**L**	**T**	**P**	**Credits**
MMM 101	III	Special Materials and their Applications	3	1	0	4
MMM 102	IV	Corrosion and its Control	3	1	0	4
MMM 103	V	Materials Characterization and Testing	3	0	2	4
MMM 104	VI	Minor Specialization Project-I	0	0	6	3
MMM 105	VII	Minor Specialization Project-II*	0	0	6	3
	Total					**18**

Course Name	**:**	**Special Materials & their Applications**
Course Code	**:**	**MMN 301**
Credits	**:**	**4**
L T P	**:**	**3 1 0**

Course Objectives
At the end of this course, student will be able to: • Impart knowledge about the basics and properties relevant to different engineering materials. • Apply the fundamental concepts of materials for applications in engineering. • To develop molecular/atomic level understanding of the smart behavior in the materials • To signify the huge potential/crucial role of smart materials/systems in the future technology development

Total No. of Lectures - 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**Electronic Materials** Energy band in solids, Density of States, P-N Junction, Metal semiconductor contacts, Bipolar junction transistor, MOSFETs, III-V and II-VI semiconductors, Metal Oxides, Carbon Nanotubes and 2 D Semiconductors.	5
Unit 2	**Dielectric Materials** Introduction, dielectric constant and polarization, linear dielectric materials, Capacitors; Polarization Mechanisms, Non-linear dielectric, Piezoelectric, Pyroelectric and Ferroelectric properties, Hysteresis and ferroelectric domains, key parameters for evaluating energy storage efficiency, dielectric breakdown field, discharge time, applications of energy storage capacitors.	7
Unit 3	**Multiferroic Materials** Origin of magnetic ordering in the oxide materials, origin of ferroic in electric diode ordering in oxide materials, coupling of magnetic and electric dipole ordering, possible materials and their engineering for multiferroic properties, application of multiferroic materials.	5
Unit 4	**Optical Materials** Optical properties of materials: optical constant, index of refraction, absorbance, reflectivity, transmissivity, Hagen-Rubens relation, atomistic theory, rates of emission and absorption, Condition for amplification by stimulated emission, laser amplifier, lasers, light emitting diodes (LEDs), OLEDs, integrated optoelectronics, modulators, switches.	5
Unit 5	**Low Temperature materials (Smart Polymers Materials)** Thermally responsive polymer, Electroactive Polymer microgels, Synthesis, Properties and Application, Protein based smart polymers, Photo-responsive polymer, Self-assembly, Drug delivery using smart polymer.	5
Unit 6	**Shape Memory Materials** Shape memory alloys, Shape memory effects, Martensitic transformation, One way and two-way, Training of SMAs, binary and ternary alloys system, Functional properties of SMAs.	5
Unit 7	**Smart Materials and Structures** System intelligence- components and classification of smart structures, common smart materials and associated stimulus-response, Application areas of smart systems	5

Unit 8	**Materials for high temperature Application** Characteristics of high temperature materials, Superalloys as high temperature materials-Single crystal super alloys for blade application, Super alloys for turbine disc applications	5

Course Outcomes:
Students will be able to-

1. Explain the structure–property relationships and operating principles of electronic and optical materials for semiconductor, optoelectronic, and photonic device applications.
2. Analyze the polarization, dielectric, and magnetoelectric behaviors of dielectric and multiferroic materials for energy storage and multistate memory device applications.
3. Evaluate the underlying mechanisms governing the behavior of smart materials; and shape memory materials for biomedical applications.
4. Select the appropriate materials based on their functional properties for advanced engineering applications (high temperature, drug delivery, etc.).

Text Book

Sr. No.	Name of Book/Authors/Publisher	Year of Publ./Reprint
1	Materials science and engineering an introduction. Callister Jr WD.	2007

Reference Books

Sr. No.	Name of Book/Authors/Publisher	Year of Publ./Reprint
1	M. Schwartz, New Materials, Processes, and Methods Technology, CRC Press	2006
2	K. Otsuka, C.M. Wayman (Eds.), Shape Memory Materials, Cambridge University Press	1998
3	M. Addington, D.L. Schodek, Smart Materials and New Technologies in Architecture, Elsevier	2005
4	I. Galaev, B. Mattiasson (Eds.), Smart Polymers: Applications in Biotechnology and Biomedicine, 2 nd ed., CRC Press	2004
5	N. Yui, R. J. Mrsny, K. Park (Eds.), Reflexive Polymers and Hydrogels: Understanding and Designing Fast Responsive Polymeric Systems, CRC Press	2007
6	The Superalloys: Fundamentals and Application. Reed RC, Cambridge University press.	2008
7	D.J. Leo, Engineering Analysis of Smart Material Systems, Wiley	2006

Equivalent MOOCs

Sr. No.	Course Links	Offered by
1	Fundamentals of Electronic Materials and Devices https://nptel.ac.in/courses/113106065	NPTEL
2	Smart Materials and Intelligent System Design https://nptel.ac.in/courses/112104251	NPTEL

CO-PO-PSO Mapping Matrix (MMN 301 Special Materials & their Applications)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	2	-	-	-	-	-	-	-	-	2	3
CO2	3	2	2	-	-	-	-	-	-	-	-	2	3
CO3	3	3	2	-	-	-	-	-	-	-	-	2	3
CO4	3	2	3	-	-	-	-	-	-	-	-	2	3

Course Name	**:**	**Physical Metallurgy**
Course Code	**:**	**MMN 302**
Credits	**:**	**4**
L T P	**:**	**3 0 2**

Course Objectives:
Students should be able - • To analyze structure-property correlations • To explore transformations in materials during solidification • To apply basic elements of Physical Metallurgy to engineering fields • To develop different alloy systems using Phase Diagrams • To enable solid-state transformations using Fick's diffusion laws

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**Structure of Solids:** Levels of Structure, structure-property relationship in materials; Crystal geometry and structure determination by X-ray diffraction; Crystalline and non-crystalline states of inorganic solids and polymers; Crystal Imperfections	6
Unit 2	**Phase Diagrams:** The Phase Rule; Single-component systems; Binary Phase diagrams; Microstructural changes during cooling; The Lever Rule; The Tie-Line Rule; The 1-2-1 Rule; Some typical Phase Diagrams to demonstrate important alloy behaviour-Isomorphous system, Eutectic system, Peritectic, eutectoid, syntactic and monotectic reaction	10
Unit 3	**Iron-carbon Alloys:** Classification and applications of Steels; Steel specifications; Cast-Irons: Development of cast irons; Types of cast iron; Formation of white cast iron, Grey cast iron and spheroidal Grey iron; AFS and ASTM specification for graphite Flakes in Grey iron and graphite nodules in SG iron.	6
Unit 4	**Diffusion in Solids:** Fick's laws of Diffusion, Solutions to Fick's second law; Applications based on the Fick's second Law Interstitial diffusion, The Krinkendall Effect, The Atomic Model of diffusion; Diffusion processes: lattice diffusion, pipe diffusion and grain boundary diffusion	4
Unit 5	**Elastic, Anelastic and Viscoelastic behaviour:** Elastic Behaviour: Atomic Model of Elastic behaviour, The Modulus as a parameter in design; Rubber like elasticity; Anelastic behaviour: Relaxation processes; Viscoelastic behaviour: Spring-Dashpot Models	4
Unit 6	**Crystal Interfaces:** Boundaries in single phase solids- low angle and high angle grain boundaries, thermally activated grain boundary migration, interfaces in solids- fully coherent, semi-coherent and incoherent interfaces, interfacial energy effects, second phase effects, examples of diffusion controlled and interface-controlled phenomena.	6
Unit 7	**Solidification:** Thermodynamics of solidification; Solidification Mechanism: Nucleation and Growth; Effect of temperature inversion at solid-liquid interface on solidification structure; Thermal and Constitutional supercooling; Microstructural development during freezing in casting ingots and welds; Segregation and Porosity formation during solidification process.	6

List of Experiments:		**No. of Turns**
1	Study of Crystal Structures through Ball Models	1
2	Metallurgical Microscope: Principles and Operations	1
3	Specimen Preparation techniques for Metallographic Analysis	1
4	Microstructural Analysis of Carbon Steels	2

5	Microstructural Analysis of Cast Iron	2
6	Microstructural Analysis of Non-Ferrous Metals: Brass & Bronze	2
7	Standard test methods for finding nodule morphology	1
8	Standard test Methods for Estimation of Grain Size	1
9	A low temperature melting alloy development of a given composition using Binary Phase Diagram	1
10	Solidification structure of developed alloy	1
11	Project: Color Metallography	1

Course Outcomes:
Students will be able to **-**

1. Analyze crystal structures, crystal defects, interfaces, and mechanical behavior of engineering materials through theoretical and microstructural characterization methods.
2. Interpret phase diagrams, diffusion phenomena, and Fe-C transformations to predict alloy microstructures and properties.
3. Design and evaluate solidification and materials processing conditions using theoretical principles and metallographic investigations.

Text Books		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Pub/ Reprint**
1	Vijendra Singh, Physical Metallurgy, SBS	2020
Reference Books		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Pub/ Reprint**
1	R. Balasubramaniam, Callister's Materials Science and Engineering, Wiley.	2014
2	Physical Metallurgy: Principles and Practice, V Raghavan, PHI	2015

Equivalent MOOCs

Sr. No.	**Course Links**	**Offered by**
1	Principles of Physical Metallurgy (https://nptel.ac.in/courses/113105024)	NPTEL
2	Principles of Physical Metallurgy (https://nptel.ac.in/courses/113105024)	NPTEL

CO-PO-PSO Mapping Matrix (MMN 302 Physical Metallurgy)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**
CO1	3	3		-	2	-	-	-	-	-	-	2	3
CO2	3	3	1	-	1	-	-	-	-	-	-	3	2
CO3	2	3	3	-	1		1	-	2	-	1	3	2

Course Name	**:**	**Extractive Metallurgy of Non-Ferrous Metals**
Course Code	**:**	**MMN 303**
Credits	**:**	**4**
L T P	**:**	**3 1 0**

Course Objectives:
Student should be able- • To analyze various mechanism of extraction and unit processes • To apply the fundamental knowledge for design of a reactor and process flow charts • To develop operational procedures used for metal extraction and refining. • To enable extraction process principles industrially feasible

Total No. Lectures: 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**Introduction to thermodynamics** Thermodynamic principles, Ellingham diagram, predominance area diagram, heat contents, standard free energy and equilibrium constant, free energy of formation, regular solutions, non-ideal solutions, Gibbs Duhem equation, activity, interaction parameter in multi component solution, reaction rate, effect of concentration and temperature on reaction rate, theory of absolute reaction rate, mass transfer between fluid and solid, heterogeneous reactions, gas solid reactions.	8
Unit 2	**Mineral Processing and Ore Concentration** Define the mineral, ore and gangue, froth floatation, electrostatic and magnetic separators, pre-concentration techniques, explorations of minerals, ore crushing and grinding	4
Unit 3	**General Methods of Extraction** Pyrometallurgy: calcination, flash roasting, smelting and smelting furnaces. hydrometallurgy: advantages, kinetics of leaching, leaching techniques and its variables, bacterial leaching., electrode position, electrolysis of aqueous solutions, electroplating	8
Unit 4	**General Methods of Refining** Principle of refining, physical methods of refining: sublimation, distillation, fractional distillation, solvent extraction, ion exchange precipitation, crystallization, liquation, fire refining, electrolytic refining, zone refining, electroslag refining	8
Unit 5	**Extractive metallurgy of various metals** Different methods of extraction of metal from oxides, sulphides, halides, The flow sheets for the production of aluminum, copper, nickel, manganese, Zinc, Tin, Gold, Silver, Magnesium, Titanium, Vanadium and Niobium	12
Unit 6	**Secondary extraction of metals** Recovery of lead (Pb) from lead acid batteries, Copper (Cu) and Tin (Sn) from copper scrape, Aluminum (Al) from red mud, Vanadium from plant liquors and red mud.	2

Course Outcomes: Students will be able to
1. Explain the thermodynamic principles, reaction kinetics, mass transfer phenomena, and fundamental unit operations involved in non-ferrous extractive metallurgy, including mineral processing, ore concentration, roasting, smelting, leaching, electrolysis, and refining processes. 2. Apply mineral processing, concentration, and refining techniques for the extraction and purification

of non-ferrous metals from various ores and mineral resources. 3. Analyze and evaluate pyrometallurgical, hydrometallurgical, and electrometallurgical extraction routes, process flowsheets, and recycling strategies for the sustainable recovery of non-ferrous metals from ores, industrial residues, spent batteries, red mud, and metallurgical wastes.

Text Book		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publ./ Reprint**
1	Extraction of Non-ferrous metals/H.S. Ray, R. Sridhar, K.P. Abraham/Affiliated East West Press	2008
Reference Books		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publ./Reprint**
1	Non-Ferrous Extractive Metallurgy - Industrial Practices/ Roger Rumbu /Create Space independent Publishing Platform	2014
2	Non-Ferrous Extractive Metallurgy/Charles Burroughs Gill/Krieger Pub Co, first edition	1988
3	Non-ferrous Metallurgy/ Dennis/ Pitman Publishing	1998

Equivalent MOOCs

Sr. No.	Course Links	Offered by
1	Principles of Extractive Metallurgy (https://nptel.ac.in/courses/113105441)	NPTEL
2	Non – Ferrous Extractive Metallurgy (https://nptel.ac.in/courses/113105021)	NPTEL

CO-PO-PSO Mapping Matrix (MMN 303 Extractive Metallurgy of Non-Ferrous Metals)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	3	2	-	-	-	-	-	-	-	-	1	3
CO2	3	2	3	-	-	-	-	-	-	-	-	1	3
CO3	3	3	3	-	-	-	-	-	-	-	-	1	3

Course Name	**:**	**Metallurgical Thermodynamics and Kinetics**
Course Code	**:**	**MMN 304**
Credits	**:**	**4**
L T P	**:**	**3 1 0**

Course Objectives
At the end of this course the student will be able to: • Understand the laws of thermodynamics and Apply them to material systems, solutions, and chemical reaction. • Be familiar to both classical thermodynamics and statistical mechanics and be able to link macroscopic to microscopic properties; • Understand phase equilibrium of single component systems and mixtures; • Describe the thermal behavior of solid materials and phase transitions; • Read, analyze, and construct phase diagrams • Derive the combined statement of the first and second laws of thermodynamics. • Calculate the configurational entropy of a multicomponent system, the standard enthalpy change, standard free energy change and standard entropy change of a phase change or chemical reaction at any temperature. • Understand and solve the reaction kinetics in different materials systems.

Total No. of Lecture-42

Lecture wise Breakup		**No. of Lectures**
Unit 1	**Law of Thermodynamics** First, second and third laws of thermodynamics, microscopic to macroscopic calculations, central limit theorem, Heat, Work, Enthalpy, Entropy, Free energy, Isothermal and adiabatic atmospheres, Gibbs Helmholtz Equations, Maxwell's relations, Clausius Clayperon equation, Stability, Configurational entropy and thermal entropy, density of states	7
Unit 2	**Behaviour of Solutions and Gases** Boltzmann distribution, partition functions, Specific heats of gases and solids, Maxwell distribution, Partial Molar properties, Gibbs Duhem equation, Ideal & Non-Ideal solutions, Raoult's Law, Henry law, Sieverts law, Regular solutions, Chemical potential, Reactions involving gases, partial pressure and oxidation.	7
Unit 3	**Phase Equilibrium** Equilibrium constant, Activity, Ellingham and phase stability diagrams, Phase equilibria, Evolution of phase diagrams, Calculation of phase diagrams in PTC space, binary and ternary phase equilibria TTT diagrams	7
Unit 4	**Phase Equilibria (Metastable)** Quantum statistics (Fermi Dirac, Bose Einstein and Maxwell Boltzmann), conduction of electrons in metals, Metastable phase diagrams, reversibility and irreversibility, Irreversible thermodynamics: coupled forces and fluxes, driving forces for diffusion, Ficks laws, solutions to Diffusion equation	7
Unit 5	**Fundamental of Kinetics** Thermodynamics versus kinetics, Reaction mechanism in homogeneous systems like solid-solidand liquid-liquid systems, Reaction mechanism in heterogeneous systems like gas-solid, solid- liquid systems, Rate controlling step and rate equation, Basics, first, second, third, and zero order reactions, Collision theory, Theory of absolute reaction rates, Activation Energy.	7
Unit 6	**Kinetics study of Metallurgical Processes** Reduction of oxide ores, solution to diffusion equation, Kinetics of carburizing, nitriding, roasting, smelting and motion of interfaces, capillary forces, coarsening, creep and sintering	7

Course Outcomes: Students will be able to:
1. Apply thermodynamic laws and formulate equilibrium conditions using enthalpy, entropy, and Gibbs free energy to determine phase stability in metal–metal and metal–oxide systems. 2. Analyze solution behavior in binary solid solutions using chemical potential, partial molar properties, Gibbs free energy concepts, and statistical thermodynamic principles. 3. Analyze diffusion and reaction kinetics in metallurgical systems using Fick's laws, diffusion equations, and rate theories to interpret transformation mechanisms. 4. Evaluate phase equilibrium behavior under varying temperature and partial pressure using Ellingham diagrams, phase diagrams, thermodynamic relations, and computational visualization tools.

Text Book		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Introduction to the Thermodynamics of Materials / David R. Gaskell /CRC Press / 6th edition	2017
Reference Books		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Fundamentals of Statistical and Thermal Physics/Frederic Rief/McGraw Hill or Waveland Press	2008
2	Kinetics of Materials/ Balluffi, Craig, Carter/Wiley	2005
3	Metallurgical Thermodynamics/Ahindra Ghosh/ Prentice hall India(P) Ltd.	2008

Equivalent MOOCs

Sr. No.	**Course Links**	**Offered by**
1	Thermodynamics and Kinetics of Materials https://archive.nptel.ac.in/courses/113/106/113106108/	NPTEL
2	Advanced Metallurgical Thermodynamics https://archive.nptel.ac.in/courses/113/106/113106031/	NPTEL

CO-PO-PSO Mapping Matrix (MMN 304 Metallurgical Thermodynamics and Kinetics)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**
CO1	3	2	-	-	-	-	–	–	–	–	-	2	3
CO2	3	2	1	-	-	-	–	–	–	–	-	2	3
CO3	3	3	2	1	-	-	–	-	-	-	-	2	3
CO4	3	3	2	2	-	1	1	1	-	-	-	2	3

Course Name	**:**	**Electric Vehicle Materials**
Course Code	**:**	**MMN 305**
Credits	**:**	**4**
L T P	**:**	**3 1 0**

Course Objectives:
Students should be able – • Classify types of batteries and suggest appropriate technologies for EVs • Establish structure - microstructure - electrical performance correlations for various components of a battery • Classify various types of supercapacitors and fuel cell and select appropriate types for EVs • Compare various rare earth and rare earth free magnet technologies for motor applications • Analyze various materials for their use as structural materials and charging infrastructure in EVs.

Total No. Lectures: 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**Introduction to Electric Vehicle (EVs) Technology** Classification of EVs, Comparison with the IC Engine Technology, e-vehicles life cycle analysis and raw material availability, Economic considerations for batteries in e-vehicles, Value chain for electric car batteries, Concept of energy density and power density, Comparative study of energy and power density of various battery technologies	6
Unit 2	**Li Ion Batteries for EVs** Structure of Li ion battery: electrolyte, cathode and anode active materials, binder and separator, Performance requirement of battery components, Electrolytes in Li-ion batteries: Synthesis, fabrication, microstructure investigation and determination of electrical properties, Chemistry of cathode and anode materials for Li-ion batteries, integration of cathode, anode and electrolyte, measurement of electrical properties of cells	8
Unit 3	**Battery Pack Manufacturing and Alternate Battery Technologies** Materials for sealing of batteries, Cell to battery pack manufacturing, electrical insulations in Battery packs, thermal management materials in battery packs, Tradeoffs between specific power, specific energy, performance, cost, life span and safety in principal Li-ion battery technologies, Recycling of battery materials, Looking beyond Li-ion batteries: Mg, Al and Fe ion batteries, pros and cons w.r.t. Li-ion batteries, Indian Scenario for Li and alternate battery materials	7
Unit 4	**Supercapacitors and Fuel Cells for EVs** Comparison with other storage technologies, Supercapacitors: principle, types and materials used, key electrical characterization techniques, Battery-supercapacitor hybrid arrangement Fuel Cells: principle(s), types and materials used, key electrical characterization techniques, Battery-fuel cell hybrid arrangement for e-vehicles, Concept of battery-biofuel hybrid arrangement	8
Unit 5	**Materials for Motors in EVs** Critical Metals for electric motors: Nd, Eu, Y, Tb, Dy; manufacturing of rare earth and rare-earth free magnets for electric motors, Comparative Study on magnetic properties of rare earth and rare-earth free magnets, Recycling of magnetic materials from motors in e-vehicles, Non magnetic motors: an emerging technology	7

Unit 6	**Structural and other Essential Materials for EV Ecosystem** Fibre reinforced composites, steels, Al etc. in EV manufacturing, Materials for charging infrastructure, Solar-EV hybrid systems, Sensor materials, Materials for communication and display systems	6

Course Outcomes:
Students will be able to

1) Explain electrochemical mechanisms and calculate performance characteristics of batteries including cell voltage, capacity, energy density, power density etc.
2) Analyze structure–microstructure–property–performance relationships of materials used in lithium-ion batteries and battery-pack manufacturing.
3) Evaluate non-Li based batteries, supercapacitors and fuel cells based on energy density, power density, efficiency, lifespan, safety and applications requirements for electric vehicles.
4) Assess magnetic, structural and infrastructure materials and recommend suitable material solutions for sustainable electric vehicle systems.

Text Book

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publ./ Reprint
1	Battery Technology Crash Course: A Concise Introduction / S. Petrovic /Springer / 1st edition	2021

Reference Books

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publ./ Reprint
1	Alternative fuels and advanced vehicle technologies for improved environmental performance: Towards zero carbon transportation /R. Folkson/ Woodhead Publishing/1st Edition	2014
2	Electric Vehicles: Modern Technologies and Trends/ N. Patel, A.K. Bhoi, S. Padmanabhan, J. Holm-Nielsen /Springer/1st Edition	2021
3	Electric Vehicles for Smart Cities: Trends, Challenges and Opportunities/E.A. Nananki/Elsevier/1st Edition	2021
4	Future Lithium Ion Batteries/A. Eftekhari/Royal Society of Chemistry/1st Edition	2019

Equivalent MOOCs: There is no equivalent MOOC available on Swayam/NPTEL platform. However, related MOOCs are listed below.

Sr. No.	Course Links	Offered by
1	Fundamentals of Electric Vehicles: Technology and Applications https://nptel.ac.in/courses/108106170	NPTEL
2	Electric Vehicles and Renewable Energy https://nptel.ac.in/courses/108106182	NPTEL

CO-PO-PSO Mapping Matrix (MMN 305 Electric Vehicle Materials)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	-	-	-	-	-	-	-	-	-	2	3
CO2	3	3	1	-	-	1	-	-	-	-	-	2	3
CO3	3	3	2	-	-	2	-	-	-	-	-	2	3
CO4	3	2	3	-	-	3	-	-	-	-	-	2	3

Course Name	**:**	**Special Materials & their Applications**
Course Code	**:**	**MMM 101**
Credits	**:**	**4**
L T P	**:**	**3 1 0**

Course Objectives
At the end of this course, student will be able to: • Impart knowledge about the basics and properties relevant to different engineering materials. • Apply the fundamental concepts of materials for applications in engineering. • To develop molecular/atomic level understanding of the smart behavior in the materials • To signify the huge potential/crucial role of smart materials/systems in the future technology development

Total No. of Lectures - 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**Electronic Materials** Energy band in solids, Density of States, P-N Junction, Metal semiconductor contacts, Bipolar junction transistor, MOSFETs, III-V and II-VI semiconductors, Metal Oxides, Carbon Nanotubes and 2 D Semiconductors.	5
Unit 2	**Dielectric Materials** Introduction, dielectric constant and polarization, linear dielectric materials, Capacitors; Polarization Mechanisms, Non-linear dielectric, Piezoelectric, Pyroelectric and Ferroelectric properties, Hysteresis and ferroelectric domains, key parameters for evaluating energy storage efficiency, dielectric breakdown field, discharge time, applications of energy storage capacitors.	7
Unit 3	**Multiferroic Materials** Origin of magnetic ordering in the oxide materials, origin of ferroic in electric diode ordering in oxide materials, coupling of magnetic and electric dipole ordering, possible materials and their engineering for multiferroic properties, application of multiferroic materials.	5
Unit 4	**Optical Materials** Optical properties of materials: optical constant, index of refraction, absorbance, reflectivity, transmissivity, Hagen-Rubens relation, atomistic theory, rates of emission and absorption, Condition for amplification by stimulated emission, laser amplifier, lasers, light emitting diodes (LEDs), OLEDs, integrated optoelectronics, modulators, switches.	5
Unit 5	**Low Temperature materials (Smart Polymers Materials)** Thermally responsive polymer, Electroactive Polymer microgels, Synthesis, Properties and Application, Protein based smart polymers, Photo-responsive polymer, Self-assembly, Drug delivery using smart polymer.	5
Unit 6	**Shape Memory Materials** Shape memory alloys, Shape memory effects, Martensitic transformation, One way and two-way, Training of SMAs, binary and ternary alloys system, Functional properties of SMAs.	5
Unit 7	**Smart Materials and Structures** System intelligence- components and classification of smart structures, common smart materials and associated stimulus-response, Application areas of smart systems	5

Unit 8	**Materials for high temperature Application** Characteristics of high temperature materials, Superalloys as high temperature materials-Single crystal super alloys for blade application, Super alloys for turbine disc applications	5

Course Outcomes

Students will be able to

1. Explain the structure–property relationships and operating principles of electronic and optical materials for semiconductor, optoelectronic, and photonic device applications.
2. Analyze the polarization, dielectric, and magnetoelectric behaviors of dielectric and multiferroic materials for energy storage and multistate memory device applications.
3. Evaluate the underlying mechanisms governing the behavior of smart materials; and shape memory materials for biomedical applications.
4. Select the appropriate materials based on their functional properties for advanced engineering applications (high temperature, drug delivery, etc.).

Text Book

Sr. No.	Name of Book/Authors/Publisher	Year of Publ./Reprint
1	Materials science and engineering an introduction. Callister Jr WD.	2007

Reference Books

Sr. No.	Name of Book/Authors/Publisher	Year of Publ./Reprint
1	M. Schwartz, New Materials, Processes, and Methods Technology, CRC Press	2006
2	K. Otsuka, C.M. Wayman (Eds.), Shape Memory Materials, Cambridge University Press	1998
3	M. Addington, D.L. Schodek, Smart Materials and New Technologies in Architecture, Elsevier	2005
4	I. Galaev, B. Mattiasson (Eds.), Smart Polymers: Applications in Biotechnology and Biomedicine, 2 nd ed., CRC Press	2004
5	N. Yui, R. J. Mrsny, K. Park (Eds.), Reflexive Polymers and Hydrogels: Understanding and Designing Fast Responsive Polymeric Systems, CRC Press	2007
6	The Superalloys: Fundamentals and Application. Reed RC, Cambridge University press.	2008
7	D.J. Leo, Engineering Analysis of Smart Material Systems, Wiley	2006

Equivalent MOOCs

Sr. No.	Course Links	Offered by
1	Fundamentals of Electronic Materials and Devices https://nptel.ac.in/courses/113106065	NPTEL
2	Smart Materials and Intelligent System Design https://nptel.ac.in/courses/112104251	NPTEL

CO-PO-PSO Mapping Matrix (MMM 101 Special Materials & their Applications)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	2	-	-	-	-	-	-	-	-	2	3
CO2	3	2	2	-	-	-	-	-	-	-	-	2	3
CO3	3	3	2	-	-	-	-	-	-	-	-	2	3
CO4	3	2	3	-	-	-	-	-	-	-	-	2	3

Course Name	**:**	**Mechanical Behavior of Materials**
Course Code	**:**	**MMN 401**
Credits	**:**	**4**
L T P	**:**	**3 1 0**

Course Objectives:
Students should be able - • Use the concepts of stress and strain to explain the elastic and plastic behaviour of the material. • Relate the mechanical behaviour of materials to dislocation theory and presence of surface defects and volume defects • Design a strength improvement process based on strengthening mechanisms for a given application • Apply mechanisms of material failures fracture, fatigue and creep for failure analysis

Total No. of Lectures –42

Lecture wise breakup		**No. of Lectures**
Unit 1	**Concepts of Stress and Types of Stress** Concepts of Stress and types of Stresses, Concepts of Strain and types of Strain, Units of stress and other quantities.	3
Unit 2	**Stress and Strain Relationships for Elastic Behaviour** Description of stress at a point, state of stress in two dimensions, state of stress in three dimensions, Description of strain at a point, Hydrostatic component of stress, Elastic Stress–Strain relations, Calculation of Stresses from Elastic Strains, Strain Energy, Anisotropy of Elastic behaviour, Stress Concentration; FEM methods	6
Unit 3	**Elements of the Theory of Plasticity** The Flow Curve, True Stress and True Strain, Yielding Criteria for ductile materials; Anisotropy in yielding; Octahedral shear stress and shear strain; Invariants of stress and strain; Plastic stress-strain relations; Two-dimensional plastic flow-Slip-Line Field.	6
Unit 4	**Plastic Deformation of Single Crystal:** Revision of crystal geometry and lattice defects; Deformation by Slip; Slip in perfect lattice and Slip by dislocation movement; Critical Resolved shear stress for Slip, Deformation of single crystals; Deformation of FCC; Deformation by Twinning; Stacking Faults; Deformation Bands and Kink Bands; Microstrain behaviour; Strain hardening of single crystal	6
Unit 5	**Dislocation Theory** Introduction; Observation of Dislocations; Burger’s Vector and Dislocation Loop; Dislocations in FCC lattice; HCP lattice and BCC Lattice: Stress Fields and Energyies of dislocations; Forces on Dislocations; Forces between the dislocations; Dislocation climb; Intersection of dislocations; Dislocation sources; Multiplication of dislocations; Dislocation-point interactions; dislocation Pile-ups.	9
Unit 6	**Strengthening Mechanisms** Grain boundaries and deformation; strengthening from grain boundaries; Low angle boundaries; Yield point phenomenon; Strain Aging; solid solution strengthening; Deformation of two-phase aggregates; Strengthening from fine particles; Fiber strengthening; Strengthening due to point defects; Martensite strengthening; Cold worked structures; Strain hardening; Annealing of cold worked metal; Bauschinger Effect: Preferred Orientation-texture	6

Unit 7	**Fracture** Types of fracture in metals- ductile fracture, brittle fracture; Theoretical cohesive strength of metals, Griffith theory of brittle fracture, Fracture of single crystal; Metallographic aspects of fracture; Fractography; Dislocation theory of brittle fracture; Notch Effects; Concepts of the Fracture Curve; Fracture under combined stresses; Effect of hydrostatic forces on fracture.	6

Course Outcomes:

Students will be able to

1. Analyze elastic and plastic deformation behavior of materials by applying stress-strain relationships, yielding criteria, and constitutive laws under various loading conditions.
2. Analyze the role of crystal defects, dislocation mechanisms, and strengthening processes in controlling deformation and mechanical properties of engineering materials.
3. Evaluate fracture behavior and failure mechanisms of materials under different stress states using fracture theories and microstructural considerations.

Text Book

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publ./Reprint
1	Mechanical Metallurgy, George E Dieter, Third Edition, Mc Graw Hill	2017

Reference Books

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publ./Reprint
1	The structure and properties of materials, volume III, Mechanical Behaviour/H.E Hayden, William G Moffatt, John Wulff /Willey Eastern Ltd	1986
2	Dislocations and mechanical Behaviour of materials/ M.N.Shetty/ PHI Learning Pvt. Ltd.	2013

Equivalent MOOCs

Sr. No.	Course Links	Offered by
1	Mechanical Behavior of Materials (Part-I) https://nptel.ac.in/courses/113104104	NPTEL
2	Mechanical Behavior of Materials (Part-II) https://nptel.ac.in/courses/113104105	NPTEL

CO-PO-PSO Mapping Matrix (MMN 401 Mechanical Behavior of Materials)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	3	1	1		-	-	-	-	-	-	2	3
CO2	3	3	2	1	1	-	-	-	-	-	-	3	3
CO3	2	3	3	2	1	-	1	-	-	-	1	3	2

Course Name	**:**	**Iron Making Technology**
Course Code	**:**	**MMN 402**
Credits	**:**	**4**
L T P	**:**	**3 1 0**

Course Objectives:
Students should be able - • To implement basic concepts of Ironmaking for integrated and primary iron production Technologies. • To analyze national and international developments trends in primary and auxiliary technologies for pig iron production and its quality • To apply the concepts of iron making for Industry and its research developments • To analyze the engineering problems and develop the possible solutions

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**General introduction to the subject:** Historical perspective; Importance and role of Iron making in human civilization; Integrated iron and steel plants; Iron and steel production in India	2
Unit 2	**Review of Thermodynamics Principles and Chemical Kinetics** Introduction to the thermodynamics and basic principles of Iron Making Ellingham diagrams; Some applications/ examples of mass-transfer in Iron Making	7
Unit 3	**Blast Furnace Design and Process** Plant layout and Auxiliary Equipment Construction, features and design of modern-day BF; BF accessories Design improvement in the recent past for efficient Iron Making Practice	7
Unit 4	**Feed Preparation** Carbonization of coal, Quality of Metallurgical Coke for Blast furnace, Iron Ore and their quality parameters, Agglomeration Techniques and their variables as blast furnace feed. Pelletization & Sintering: Fundamentals; Temperature profile and heat input; physio-chemical changes and underlying mechanisms	7
Unit 5	**Physio Chemical changes in Blast Furnace and Structure of Slag** The physio chemical change of the furnace, Kinetics of BF reactions in the stack-kinetics of reduction of iron oxides and kinetics of carbon gasification; BF reactions and relevant systems in stack, bosh and hearth. Combustion of coke in the tuyere zone; Equilibria between gases and solids in the BF stack; Slag – its types, nature and properties for efficient operation	7
Unit 6	**Irregularities and improvements in design &operations of BF** Irregularities in the blast furnace operation and their remedies Improvement in blast furnace operation with High top pressure, Humidification, Oxygen enrichment etc. Advances in Use of slag,	3
Unit 7	**Auxiliary Environmentally Sustainable Technologies** Low shaft Furnace – Introduction, operation, and applications Sponge iron technique – Operation and thermodynamics Gas-based DRI production- Midrex process: Basic principle; Reforming of natural gas Liquid hot metal producing technologies or smelting reduction (SR) processes - Corex process Recent advances of Iron Making towards sustainable technologies: Use of By Products and emission control	7
Unit 8	Summary: BF and the need to move towards sustainable and greener processes for ironmaking	2

Course Outcomes: Students will be able to
1. Explain the national & international importance of Iron Making Technology, its thermodynamic principles, kinetics & mass transfer phenomena, feed preparation methods & physicochemical processes governing blast furnace and auxiliary technologies including coal-based DRI, MIDREX, COREX, and other sustainable ironmaking routes. 2. Apply the principles of Iron Making through reactions, kinetics, phase equilibria & material balances to calculate process parameters such as burden composition, coke rate, blast requirements, gas composition, heat balance, and slag characteristics in ironmaking. 3. Analyze the influence and corelation of raw material & irregularities in operation, operating parameters, reaction mechanisms, and process variables on the performance, productivity, energy efficiency, product quality, and environmental sustainability of blast furnace and alternative ironmaking processes. 4. Evaluate blast furnace and emerging ironmaking technologies, challenges and advancements in existing/ upcoming auxiliary technologies for their process efficiency, energy utilization, environmental impact, and industrial applicability.

Text Book		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publ./ Reprint**
1	Principles of Blast Furnace Iron Making, Cootha Publishing House, Brisbane by A.K Biswas	1981
Reference Books		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publ./ Reprint**
1	The manufacture of iron and steel (Vol. I and III) Bash forth, R.G	1951/2005
2	Iron and Steel Production /K. Bugayev, Y. Konovalov / Books for Business	2001
3	Iron Making And Steelmaking: Theory And Practice / Ahindra Ghosh, Amit Chatterjee / Prentice Hall India	2011
4	A First Course in Iron and Steelmaking: by D. Mazumdar, University Press, Hyderabad,	2015
5	Related papers on Rotary Kiln, Midrex and Corex technologies (to be distributed in class) Tupkrey	

Equivalent MOOCs

Sr. No	**Course Links**	**Offered by**
1	Ironmaking and Steelmaking https://onlinecourses.nptel.ac.in/noc20_mm23/preview	Swayam
2	Ironmaking https://nptel.ac.in/courses/113108079	NPTEL

CO-PO-PSO Mapping Matrix (MMN 402 Iron Making Technology)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**
CO1	3	2	-	-	-	-	-	-	-	-	-	2	3
CO2	3	3	-	-	-	-	-	-	-	-	-	2	3
CO3	3	3	-	-	-	-	-	-	-	-	-	2	3
CO4	3	3	-	-	-	2	-	-	-	-	-	2	3

Course Name	**:**	**Phase Transformations and Heat treatment**
Course Code	**:**	**MMN 403**
Credits	**:**	**4**
L T P	**:**	**3 0 2**

Course Objectives:
Students should be able - • To explore the transformation of phase in new steels • To analyze the effect of time and temperature on microstructure, • To apply the knowledge to correlation of time and temperature of treatment with microstructure, apply the TTT/CCT diagram for desired microstructure • To develop heat treatment cycle for given structural or property requirement

Total No. Lectures: 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**Thermodynamics** Gibbs free energy, equilibrium and chemical potential, Gibbs phase rule, Gibbs free energy vs. composition diagram, Types of binary phase diagrams, Lever rule, phase rule, ternary diagrams, kinetics of phase transformations	7
Unit 2	**Crystal interface and microstructure** Interfacial free energy, solid/vapour Interfaces, boundaries in single phase solids, interphase in interfaces solids, interface migration, interstitial diffusion, substitutional diffusion	7
Unit 3	**Transformations** Liquid to solid transformation, homogeneous nucleation, heterogeneous nucleation, nucleation and growth rate. eutectic transformation Cellular precipitation, spinodal decomposition, ordering transformations, diffusionless transformations	7
Unit 4	**Principles of Heat Treatment** Heat treatment process variables, formation of austenite, decomposition of austenite, TTT and CCT, effect of alloying elements, carbon, grain size on TTT curve, Pearlitic transformation, bainitic transformation, martensitic transformation.	7
Unit 5	**Heat Treatment Processes** Annealing, Normalizing, Spheriodizing, Hardening, Tempering, Austempering, Martempering, Subzero treatment, Patenting.	7
Unit 6	**Hardenability, Hardening and Thermomechanical Treatment:** Hardenability, Jominy end quench test, carburizing, cyaniding, nitriding, flame hardening, induction hardening, measurement of case depth, ausforming, isoforming, marstraining, cryoforming	7

List of Experiments:		**No. of Turns**
1	Normalizing treatment of steel and comparison of the microstructure with annealed structure.	2
2	To perform hardening and study the quenched structures of steel – quenched in oil, water and brine solution.	2
3	To perform hardening and tempering and study the tempered structures of steel	3
4	To perform cold working followed by recrystallization and study the recrystallization behavior of Al	2
5	Determination of hardenability of steels using Jominy End Quench Test	2
6	To carry out age hardening of non ferrous alloys. (Al-Cu alloy such as 2024)	2

7	To perform the Carburizing treatment and to study the effect of time on the Case depths of carburized steel.	1

Course Outcomes:
Students will be able to

1. Explain thermodynamic principles governing phase transformations and interpret phase equilibria using phase diagrams, Gibbs free energy concepts and phase rule.
2. Apply phase transformation principles and heat treatment concepts, including austenite transformation to pearlite, bainite and martensite using TTT/CCT diagrams and heat treatment processes to predict microstructural evolution and strength and toughness in plain carbon and alloy steels.
3. Analyze the influence of time, temperature and composition on liquid-solid and solid-solid phase transformations, and correlate the resulting transformation products and microstructure with mechanical properties including strength, toughness, fatigue and creep resistance.
4. Evaluate the effectiveness of heat treatment processes (e.g. annealing, normalizing, hardening and tempering) in achieving desired microstructure, hardness and hardenability in plain carbon steels and Al-Cu alloys through metallographic analysis and laboratory experimentation while adhering to standard laboratory practices and safety procedures.

Text and Reference Books

Sr. No	Name of Book/ Authors/ Publisher	Year of Publ./ Reprint
1	Phase Transformations in Metals and Alloys / David A. Porter, Kenneth E. Easterling, and Kenneth E. Easterling / CRC Press / 3rd edition	2009

Reference Books

Sr. No	Name of Book/ Authors/ Publisher	Year of Publ./ Reprint
1	Heat Treatment: Principles and Techniques/Ashok Rajan, T.V. Sharma, C.P. Sharma /PHI Learning Private Limited/2nd edi.	2012
2	Physical Metallurgy Principles/ Reza Abbaschian, Robert E. Reed-Hill/ Cengage Learning/ 4th edition	2008
3	Principle of Heat treatment of Steels/ R.C. Sharma/ New Age International (P) Limited	2018
4	Solid State Phase transformations/ V. Raghvan	2004

Equivalent MOOCs

Sr. No.	Course Links	Offered by
1	Phase Transformation in Materials https://nptel.ac.in/courses/112104220	NPTEL
2	Phase Transformations and Heat Treatment https://nptel.ac.in/courses/113101003	NPTEL

CO-PO-PSO Mapping Matrix (MMN 403 Phase Transformations and Heat treatment)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	-	-	-	-	-	-	-	-	1	2	3
CO2	3	3	-	-	1	-	-	-	-	-	1	2	3
CO3	3	3	3	-	2	-	-	1	-	-	1	3	3
CO4	3	3	3	-	1	-	-	2	2	-	1	3	2

Course Name	**:**	**Corrosion and its Control**
Course Code	**:**	**MMN 404**
Credits	**:**	**4**
L T P	**:**	**3 1 0**

Course Objectives:
At the end of this course, the student will be able to: • Understand the fundamental of degradation and corrosion of materials in various environments. • Solve corrosion problems and design corrosion protection mechanisms.

Total No. of Lectures –42

Lecture wise breakup		**No. of Lectures**
Unit 1	Importance and cost of corrosion, thermodynamics of corrosion, passivation, Pourbaix diagram, The mixed potential theory of corrosion and its application to understand the influence of oxidizers, effect of velocity of the medium	8
Unit 2	Mechanism of oxidation, Pilling-Bedworth Ratio for oxides, Oxidation resistant materials	3
Unit 3	The Principles of corrosion, The electrodes potential, electrochemical series, Galvanic Series, Galvanic corrosion: area relationship in both active and passive states of metals. Computation of corrosion rate.	4
Unit 4	Different forms of corrosion and their control viz., uniform corrosion, galvanic corrosion, selective leaching, crevice corrosion, filliform corrosion, pitting corrosion, intergranular corrosion, erosion corrosion, fretting damage, stress corrosion cracking, corrosion fatigue, hydrogen embrittlement and microbes induced corrosion.	8
Unit 5	Corrosion testing procedures: Salt spray method, ASTM Copper strip corrosion standards, Electrochemical Testing, Immersion Testing, Cyclic Testing, Accelerated testing, Crevice Corrosion testing, evaluation of environmentally assisted cracking, evaluating localized cracking,	8
Unit 6	Inhibitors: Principles, Mechanisms and Applications, Types of Inhibitors and Their uses, Case studies	3
Unit 7	Corrosion Control Methods: cathodic protection, anodic protection, materials selection, Corrosion control Case studies from aerospace, automobile, oil and gas, refinery, petrochemical, pharmaceutical, paper and pulp industries, nuclear and thermal power plant.	8

Course Outcomes: Students will be able to
1. Apply electrochemical and thermodynamic principles to explain corrosion processes, passivation behaviour, mixed potential theory and oxidation phenomena in engineering materials. 2. Interpret electrochemical series, galvanic series and Evans diagrams to predict corrosion behaviour and estimate corrosion rates under different environmental conditions. 3. Analyze various forms of corrosion and evaluate corrosion testing data to identify degradation mechanisms in engineering applications. 4. Design appropriate corrosion prevention and control strategies through material selection, inhibitors, cathodic protection, anodic protection and other mitigation techniques for industrial systems.

Text Books		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publ./ Reprint**
1	Corrosion Engineering / Fontana / Tata McGraw Hill/ 3rd edition	2008

Reference Books

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publ./ Reprint
1	An Introduction to Electrometallurgy/ Satya Narain, Rajendra Sharan / Standard PublishersDistributors/ 2nd edition	1991
2	Electrochemistry and Corrosion Science / Nestor Perez / Springer US/ 1st edition	2004
3	Fundamental Aspects of Electro Metallurgy / K. Popov, B. Grgur, S.S. Djokic / Springer US/1st edition	2013

Equivalent MOOCs

Sr. No.	Course Links	Offered by
1	Aqueous Corrosion and its Control https://nptel.ac.in/courses/113101098	NPTEL
2	Corrosion Protection Methods https://nptel.ac.in/courses/113104108	NPTEL

CO-PO-PSO Mapping Matrix (MMN 404 Corrosion and its Control)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	-	-	-	-	-	-	-	-	-	2	3
CO2	3	3	-	-	-	-	-	-	-	-	-	2	3
CO3	3	3	2	-	-	-	-	-	-	-	-	2	3
CO4	3	3	3	-	-	2	-	-	-	-	-	2	3

Course Name	**:**	**Metal Casting Technology**
Course Code	**:**	**MMN 405**
Credits	**:**	**4**
L T P	**:**	**3 0 2**

Course Objectives:
All the end of this course, the student will be able to • Explain basics of metal casting, its types, designing patterns cores and molding. • Describe sand casting process, foundry melting furnaces. • Design for feeding and gating. • Establish structure property correlation with casting process and casting defects.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**Introduction** Casting as a process of Manufacturing, History of casting practices, Basic steps involved in the making of sand casting, Process chart of casting, Layout of a foundry, The features of casting problem; a survey and scope of foundry industry.	5
Unit 2	**Patterns and Core Making** Types, allowances, functions, materials used for pattern, Core making and machine used, various core making processes, venting, core assembly, core setting, core prints and chaplets, Chills, core knock out and disposal, testing of core sand and core coatings, cores and casting defects, Core dryer and Air circulation.	9
Unit 3	**Molding Processes, Equipment and Molding Sands** Molding processes, Molding machines with their functions & characteristics, General properties of molding sands, basic ingredients, additives, testing of molding sands	10
Unit 4	**Pouring and Feeding of Casting** Chvorinov's rule, Pouring ladles, gating system, progressive and directional solidification, types of gates, design of gating system, fluid flow, factors involved in gating design, pouring time, choke area, sprue- runner- gate ratios, Riser-theoretical considerations, function, shape, location, types, Shakeout, Fettling, Cleaning of Casting	9
Unit 5	**Inspection and Remedies of Casting Defects** Casting defects such as shrinkage and porosity, etc, quality assurances, diagnosis techniques, remedies by improvement in process and products	7
Unit 6	**Energy Conservation and Environment Protection** Heat balance and mass balance	2

List of Experiments:		**Number of Turns**
1	To study the size, shape and distribution of pure dry silica sand sample.	1
2	To find out the clay content, moisture content, permeability, AFS number, mold hardness, core hardness of the given moulding sand.	2
3	Investment casting (Lost wax casting) of aluminum and brass	1
4	To study the structure after melting and casting of the following metals tin, zinc , Al-alloy	6

5	To study the casting defects of components developed above using Non-destructive tests	3
6	Demonstration of material flow and solidification using simulation software	1

Course Outcomes: Students will be able to
1. Explain the fundamentals of casting processes, foundry practices, pattern making, and core manufacturing techniques used in sand casting. 2. Apply the molding processes, molding equipment, molding sand properties, and their influence on casting quality and productivity. 3. Interpret casting defects, recommend corrective measures, and apply quality assurance, energy conservation, and environmental protection principles in foundry operations. 4. Analyze microstructure of casting, solidification principles, design gating and feeding systems and riser design concepts, Evaluate casting parameter.

Text Books		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publ./ Reprint**
1	Metal Casting & Joining / K C John / PHI	2015
Reference Books		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publ./ Reprint**
1	Principles of Metal Casting / P L Jain / Tata Mcgraw Hill	2003
2	Casting Technology and Cast Alloys / A K Chakrabarti / PHI	2008
3	Principles of Metal Casting / Heine, Loper and Rosenthal / Tata McGraw Hill	2010
4	Fundamentals of Metal Casting Technology / P C Mukherjee / Oxford and IBH publishing Co.	1998

Equivalent MOOCs

Sr. No.	**Course Links**	**Offered by**
1	Metal casting https://www.youtube.com/watch?v=0iezQ4IeXsc&t=541s	NPTEL
2	Principles of casting technology https://www.youtube.com/watch?v=TBzKT7_fY2c&list=PLSGws_74K01__iWAP4lwiDf7jQVCndMi2	NPTEL
3	Fundamentals of manufacturing processes https://www.youtube.com/watch?v=jdFrBtHeJbs&list=PLSGws_74K01-g9nnTMBssGURHawYYQfMQ	NPTEL

CO-PO-PSO Mapping Matrix (MMN 405 Metal Casting Technology)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**
CO1	3	3	3	-	-	-	-	-	-	-	-	2	3
CO2	3	3	3	1	-	-	-	-	-	-	-	3	3
CO3	3	3	3	-	-	-	-	-	-	-	-	3	3
CO4	2	3	3	3	-	-	-	-	-	-	-	3	3

Course Name	**:**	**Corrosion and its Control**
Course Code	**:**	**MMM 102**
Credits	**:**	**4**
L T P	**:**	**3 1 0**

Course Objectives:
At the end of this course, the student will be able to: • Understand the fundamental of degradation and corrosion of materials in various environments. • Solve corrosion problems and design corrosion protection mechanisms.

Total No. of Lectures –42

Lecture wise breakup		**No. of Lectures**
Unit 1	Importance and cost of corrosion, thermodynamics of corrosion, passivation, Pourbaix diagram, The mixed potential theory of corrosion and its application to understand the influence of oxidizers, effect of velocity of the medium	8
Unit 2	Mechanism of oxidation, Pilling-Bedworth Ratio for oxides, Oxidation resistant materials	3
Unit 3	The Principles of corrosion, The electrodes potential, electrochemical series, Galvanic Series, Galvanic corrosion: area relationship in both active and passive states of metals. Computation of corrosion rate.	4
Unit 4	Different forms of corrosion and their control viz., uniform corrosion, galvanic corrosion, selective leaching, crevice corrosion, filliform corrosion, pitting corrosion, intergranular corrosion, erosion corrosion, fretting damage, stress corrosion cracking, corrosion fatigue, hydrogen embrittlement and microbes induced corrosion.	8
Unit 5	Corrosion testing procedures: Salt spray method, ASTM Copper strip corrosion standards, Electrochemical Testing, Immersion Testing, Cyclic Testing, Accelerated testing, Crevice Corrosion testing, evaluation of environmentally assisted cracking, evaluating localized cracking,	8
Unit 6	Inhibitors: Principles, Mechanisms and Applications, Types of Inhibitors and Their uses, Case studies	3
Unit 7	Corrosion Control Methods: cathodic protection, anodic protection, materials selection, Corrosion control Case studies from aerospace, automobile, oil and gas, refinery, petrochemical, pharmaceutical, paper and pulp industries, nuclear and thermal power plant.	8

Course Outcomes: Students will be able to:
1. Apply electrochemical and thermodynamic principles to explain corrosion processes, passivation behaviour, mixed potential theory and oxidation phenomena in engineering materials. 2. Interpret electrochemical series, galvanic series and Evans diagrams to predict corrosion behaviour and estimate corrosion rates under different environmental conditions. 3. Analyze various forms of corrosion and evaluate corrosion testing data to identify degradation mechanisms in engineering applications. 4. Design appropriate corrosion prevention and control strategies through material selection, inhibitors, cathodic protection, anodic protection and other mitigation techniques for industrial systems.

Text Books		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publ./ Reprint**
1	Corrosion Engineering / Fontana / Tata McGraw Hill/ 3rd edition	2008

Reference Books

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publ./ Reprint
1	An Introduction to Electrometallurgy/ Satya Narain, Rajendra Sharan / Standard PublishersDistributors/ 2nd edition	1991
2	Electrochemistry and Corrosion Science / Nestor Perez / Springer US/ 1st edition	2004
3	Fundamental Aspects of Electro Metallurgy / K. Popov, B. Grgur, S.S. Djokic / Springer US/1st edition	2013

Equivalent MOOCs

Sr. No.	Course Links	Offered by
1	Aqueous Corrosion and its Control https://nptel.ac.in/courses/113101098	NPTEL
2	Corrosion Protection Methods https://nptel.ac.in/courses/113104108	NPTEL

CO-PO-PSO Mapping Matrix (MMM 102 Corrosion and its Control)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	-	-	-	-	-	-	-	-	-	2	3
CO2	3	3	-	-	-	-	-	-	-	-	-	2	3
CO3	3	3	2	-	-	-	-	-	-	-	-	2	3
CO4	3	3	3	-	-	2	-	-	-	-	-	2	3

Course Name	:	Steel Making Technology
Course Code	:	MMN 501
Credits	:	4
L T P	:	3 0 2

Course Objectives:
Students should be able - • To implement concepts of steelmaking for integrated and primary production theories • To analyze national and international developments in primary and auxiliary technologies for steel production • To apply the concepts for Industry and research developments in steel making • To analyze the engineering problems and develop the possible solutions • To design and perform experiments to understand the aspects of physiochemical change and solidifications.

Total No. of Lectures – 42

Lecture wise breakup		No. of Lectures
Unit 1	**Steel Production – India and World Scenario:** Steel: As Engineering material and its applications National targets for steel production and planning at national level. International outlook on production and the technologies. Challenges at national and international levels	2
Unit 2	**Thermodynamics and Physiochemical Principles:** The thermodynamic principles of steel making involving and Physio chemical aspects of steel making reactions, the controlling/removal parameters for carbon, sulphur, phosphorous, silicon & manganese, Slags of Steel Making, their properties and the theories involved in the mass transfer	7
Unit 3	**Technologies of Steel Production:** Basic Oxygen Processes – Principle of Operation & mechanism for Bessemer, LD, Kaldo process - details, construction, principle for operation. Electric Arc Furnace – Process details, mechanism and advancements	7
Unit 4	**New Developments in Steel Making:** Modern pneumatic process and their development. Secondary processes of steel refining viz. Ladle furnace, AOD, VOD, and ESR. Ladle de-siliconization, de-sulphurization, de-phosphorization	9
Unit 5	Clean steel practices: Gas Metal Interaction and Mechanism of gas absorption during different Teeming. Deoxidation practices and inclusions in steel, vacuum degassing, inert gas stirring, powder injection. Vacuum, Argon and Recycling methods employed for degasification of steel.	7
Unit 6	Solidification of Steel & Continuous casting: Heat transfer and segregation during ingot casting and continuous casting. Solidification of Steels and dissolved gas effect on Ingot types and defects, CCP & latest developments	7
Unit 7	Environmental Concerns: Challenges, advances and future course of technology in tune with legislations at National and International level.	3

Sr. No	List of Experiments	No. of Turns
1	To calculate calorific values solid fuels and design parameters to improve it in given sample	2
2	To undertake Proximate analysis of solid fuel sample	2
3	To design experiment to study Oxidation and Reduction kinetics of the samples	2

4	Sintering the Iron ore fines to produce the agglomerates	2
5	Palletization of a designed the self-reducing bulk of iron ore fines with coal to study reduction	2
6	To study the effect of superheat of the liquid on the variation of Primary and Secondary piping during Ingot casting.	2
7	Designing and performing the experiment on wax casting to understand directional solidifications in wax to reduce casing defect and segregation	2

Course Outcomes:
Students will be able to

1. Explain the national & international scenario in Steel Making technology and production, its related thermodynamic principles, physicochemical reactions, slag chemistry, and process fundamentals governing primary and secondary steelmaking.
2. Apply the principles of metallurgical thermodynamics, process kinetics, mass transfer, and heat transfer to calculate process operating parameters and efficiency of thermal/ thermodynamic processes involved in production of steel.
3. Analyze the influence and control of variables of Steel Making in present day technology including the possible future advancement in the control of temperature, slag chemistry, oxygen potential, refining conditions, gas–metal interactions, and solidification parameters on steel quality, process efficiency and product defects
4. Evaluate primary and secondary steelmaking technologies, clean steel practices, and sustainable steel production routes based on process efficiency, steel quality, energy utilization, environmental considerations, and industrial applicability.

Text Book

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publ./ Reprint
1	A First Course in Iron and Steelmaking: by D. Mazumdar, University Press, Hyderabad,	2015

Reference Books

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publ./ Reprint
1	The manufacture of iron and steel (Vol. II and IV) Bash forth, R.G	1951/2005
2	Iron and Steel Production /K. Bugayev, Y. Konovalov / Books for Business	2001
3	Iron Making And Steelmaking: Theory And Practice / Ahindra Ghosh, Amit Chatterjee / Prentice Hall India	2011
4	Steel Making / A.K. Chakrabarti / Prentice-Hall of India Pvt. Ltd	2007
5	Making, Shaping and Treating of Steel / David H. Wakelin/ The AISE Steel Foundation/1st Edition	1999

Equivalent MOOCs

Sr. No.	Course Links	Offered by
1	Steel Making https://nptel.ac.in/courses/113104059	NPTEL
2	Steel Making https://nptel.ac.in/courses/113104013	NPTEL

CO-PO-PSO Mapping Matrix (MMN 501 Steel Making Technology)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	-	-	-	-	-	-	-	-	-	2	3
CO2	3	3	-	-	-	-	-	-	-	-	-	2	3
CO3	3	3	-	2	-	-	-	-	-	-	-	2	3
CO4	3	3	-	2	-	2	-	-	-	-	-	2	3

Course Name	**:**	**Advanced Materials Processing**
Course Code	**:**	**MMN 502**
Credits	**:**	**4**
L T P	**:**	**3 1 0**

Course Objectives
At the end of this course the student will be able to: • Understand the fundamentals of dislocation theory and apply them to metal plasticity. • Become familiar with metal forming techniques including rolling, extrusion, wire drawing, forging, pilgering, sheet metal forming, hydroforming, superplastic forming • Understand, identify and analyze the microstructural evolution in hot and cold metal forming operations • Learn and Understand the fundamentals of ceramic processing methods and characterization of prepared components for mechanical and physical properties • Learn and Understand the fundamentals of Powder metal processing methods and characterization of prepared components for mechanical and physical properties • Learn the fundamentals of Additive manufacturing of Polymers by 3D printing • Learn the fundamentals of Additive manufacturing of metals, its scope and challenges

Total No. of Lecture-42

Lecture wise Breakup		**No. of Lectures**
Unit 1	**Metal Processing: Basics of plasticity** Yield criterion, dislocation plasticity, twinning induced plasticity, flow stress determination, strain rate effects, residual stress, thermomechanical processing and microstructural evolution, plastic instability and superplasticity, workability	7
Unit 2	**Metal forming techniques:** Introduction to rolling, extrusion, wire drawing, forging, pilgering, sheet metal forming, hydroforming, superplastic forming: calculation of forming load, analysis of rolling load and variables, rolling defects, extrusion equipment, deformation, friction and defects in extrusion, seamless pipe tubing, Rod and wire drawing, residual stress in rods, wires and tubes, Sheet metal forming, shearing and blanking, deep drawing, forming limit diagram, defects in parts	7
Unit 3	**Microstructural evolution in Thermomechanical processing:** Hot and cold working, microstructure evolution, Defects in TMP: form defects, surface defects, fracture related defects, strain localizations. Physical simulation of properties: tensile and compression testing, hot torsion tests, mixed strain path tests, typical formability tests	7
Unit 4	**Powder ceramic processing** Kroger-Vink notation, Ceramic Powder production, characterization, batch calculations, milling, compaction, liquid and solid phase sintering, post sintering processing - HIP and Heat treatments; physical and mechanical evaluation of formed P/M parts, density and porosity determination, flexure testing, XRD, applications and case studies	7
Unit 5	**Powder Metal Processing** Fe based Powder grades and nomenclature, Powder production, characterization, admixed and premixed powders, batch calculations, milling, compaction, liquid and solid phase sintering, environment control, post sintering processing - HIP and Heat treatments; metallurgical evaluation of formed P/M parts, density and porosity determination, TRS testing, applications and case studies,	7

Unit 6	**Additive manufacturing** Introduction to additive manufacturing: CAD modeling, slicing, printing, advantages and limitations. Basics of polymer 3D printing, choice of polymers, defects in AM parts, their characterization and prevention. Liquid and solid AM. Metal AM-challenges and advantages, gas atomized powders and HIP treatment; corrosion fatigue and fracture behavior	7

Course Outcomes:
Students will be able to: 1. Explain the principles of plastic deformation, thermomechanical processing, powder metallurgy, ceramic processing, and additive manufacturing used for advanced materials fabrication. 2. Analyze the effect of processing parameters such as strain, strain rate, temperature, compaction pressure, sintering conditions, and printing variables on microstructural evolution and defect formation. 3. Evaluate density, porosity, flexural strength, transverse rupture strength (TRS), forming load, residual stresses, tensile, compressive, hot torsion and formability of processed components.

Text Book		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Mechanical Metallurgy / George E Dieter / McGraw Hill	1986
Reference Books		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Ceramic Processing/ M.N. Rahaman/ CRC, Taylor and Francis	2017
2	MPIF Standard 35/MPIF USA	2021
3	Additive Manufacturing Technologies /Ian Gibson/ Springer	2021

Equivalent MOOCs

Sr. No.	**Course Links**	**Offered by**
1	Metal forming techniques https://archive.nptel.ac.in/courses/112/107/112107250/	NPTEL
2	Powder metallurgy https://archive.nptel.ac.in/courses/113/106/113106098/	NPTEL
3	Metal Additive manufacturing https://archive.nptel.ac.in/courses/112/104/112104312/	NPTEL

CO-PO-PSO Mapping Matrix (MMN 502 Advanced Materials Processing)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	3	2	-	-	-	-	-	-	-	-	2	3
CO2	3	3	3	-	-	-	-	-	-	-	-	2	3
CO3	3	3	3	-	-	-	-	-	-	-	-	3	3

Course Name	**:**	**Welding Technology**
Course Code	**:**	**MMN 503**
Credits	**:**	**4**
L T P	**:**	**3 1 0**

Course Objectives:
Students should be able - • To analyze various process of welding • To apply the fundamental knowledge to design welding electrodes • To develop joint and analysis capability for sustaining joint for service • To enable to understand welding metallurgy

Total No. of Lectures – 42

LECTURE WISE BREAKUP		**No. of Lectures**
Unit 1	**Introduction** Process introduction, industrial relevance of welding	1
Unit 2	**Heat source in welding** Heat source efficiency, heat source efficiency of various processes, melting efficiency, power density distribution, electrical characteristics of an arc. Type of welding arcs, methods of arc maintenance, role of electrode, polarity and arc stability. AC and DC welding power sources, rectified DC welding power source, high frequency units for arc control. Metal transfer, modes of metal transfer. Analysis of heat source in welding, Rosenthal's equations, Adam equations, cooling rate and temperature distribution, welding equipment and welding operations	8
Unit 3	**Fusion Welding Processes** **Gas welding**: Oxyacetylene welding (OAW), **Arc welding**: Shielded metal arc welding (SMAW), gas–tungsten arc welding (GTAW), plasma arc welding (PAW), gas–metal arc welding (GMAW), Flux-cored arc welding (FCAW), submerged arc welding (SAW), electroslag welding (ESW), **High-energy beam welding**: Electron beam welding (EBW), laser beam welding (LBW), Joint designs, welding electrodes, characteristics of welding electrodes, heat affected zone	10
Unit 4	**Solid state welding processes** Friction welding, friction stir welding, friction stir processing, resistance welding, explosive welding, ultrasonic welding, diffusion bonding Allied processes: Soldering, brazing, metal surfacing and spraying	7
Unit 5	**Welding Metallurgy** Weld metal solidification: epitaxial & non-epitaxial growth at fusion boundary, competitive growth in bulk fusion zone, effect of welding parameters on grain structure, weld metal nucleation mechanisms, control of grain structure, solidification modes, dendrites and cell spacing, refining of microstructures, ferrite to austenite transformation in Stainless steel welds, Austenite to ferrite transformation in low carbon and low alloy steels welds, micro segregations and macro segregations, weld metal solidification cracking, partially melted zones.	9
Unit 6	**Defects in welding** Classification of various welding defects, liquation cracking, hydrogen cracking and remedies. Case studies on welding defects and its rectifications	4
Unit 7	**Quality assurance** Quality assurance of welded joints (NDT, safety, measurement and control) IS codes and specifications for welding materials and practices	3

Course Outcome: Students will be able to
1. Explain the fundamentals of welding technology, industrial applications, welding heat sources, arc characteristics, power sources, heat transfer, and temperature distribution during welding processes. 2. Analyze the influence of welding parameters on weld quality and select appropriate fusion welding processes, welding consumables and joint designs. 3. Evaluate the characteristics of solid-state joining processes for better joint performance. 4. Interpret weld metal solidification behavior, microstructural evolution, phase transformations, segregation phenomena, and welding-related metallurgical defects in welded joints.

Text Book		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publ./ Reprint**
1	Welding Engineering and Technology 2nd Edition/RS Parmar/Khanna Publisher New Delhi	2002
Reference Books		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publ./ Reprint**
1	Welding Metallurgy 2nd edition/Sindo Kou/John Willed USA	2003
2	Welding and Welding Technology/Richard Little/Tata McGraw Hill	2001
3	Welding Technology / Bruce Stirling / DhanapatRai Publishing Company Pvt. Ltd	2013
4	Welding Technology and Design / Radha Krishnan, VM, Newage International Pvt. Ltd.	2008

Equivalent MOOCs

Sr. No.	Course Links	Offered by
1	Welding Processes https://nptel.ac.in/courses/113106087	NPTEL
2	Welding Metallurgy https://nptel.ac.in/courses/113107092	NPTEL

CO-PO-PSO Mapping Matrix (MMN 503 Welding Technology)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	2	-	-	-	-	-	-	-	-	1	3
CO2	3	3	3	-	-	-	-	-	-	-	-	2	3
CO3	3	3	3	-	-	-	-	-	-	-	-	2	3
CO4	3	2	3	2	-	-	-	-	-	-	-	2	3

Course Name	**:**	**Materials Characterization and Testing**
Course Code	**:**	**MMN 504**
Credits	**:**	**4**
L T P	**:**	**3 0 2**

Course Objectives:
• To understand the fundamental concepts of different characterization methods. • To analyze characterization methods for the determination of the result of composition, structure, and properties of materials. • To integrate multiple techniques for comprehensive material analysis, enabling a holistic understanding of materials' properties. • Acquire proficiency in data analysis, pattern recognition, and interpretation specific to each technique

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**Macroscopic Examination** Introduction, Importance & scope of Macro etching, Sulphur/Phosphorus/Oxide Printing, Flow Lines	3
Unit 2	**Microscopic Examination** Preparation, and etching of Specimens of metals & alloys, Principle, Construction & working of metallurgical microscope, Optical Microscope and its types, Defects in lenses & their remedies, Applications: Phase identification, grain size measurement etc.,	6
Unit 3	**Spectroscopic Analysis** Introduction to spectroscopy, FTIR and UV-Vis spectroscopy and X-ray Fluorescence (XRF). Atomic Absorption spectroscopy(AAS), Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES), Inductively Coupled Plasma Mass Spectroscopy (ICP-MS)	7
Unit 4	**Electron Microscopy** Scanning Electron Microscope (SEM): Principle, construction, and working of SEM, Interaction of electron beam with the specimen, Study of fractured surfaces, Energy and wavelength dispersive spectroscopy, Introduction to Transmission Electron Microscopy (TEM)	6
Unit 5	**X-Ray Diffraction** Bragg's condition of diffraction, X-ray scattering, application of X-ray diffraction- phase identification, estimation of crystallite size, residual stress,	5
Unit 6	**Mechanical Testing** Tensile testing, Hardness testing: Brinell, Rockwell and Brinell hardness, Impact testing: Charpy and Izod testing, wear and friction testing, and Nano-indentation.	5
Unit 7	**Non-Destructive Testing** X-ray/Gamma-ray radiography, Ultrasonic testing, Magnetic methods- Magnetic particle test/Magna Flux, Zyglo/Die penetration test, Eddy current test.	6
Unit 8	**Thermal Analysis** Principles of Differential Scanning Calorimetry (DSC), Differential Mechanical Thermal Analysis (DMTA), and Thermogravimetric Analysis (TGA)	4

List of Experiments:		**Number of Turns**
1	To study the segregation of sulfur and phosphorus by sulfur printing and phosphorus printing.	1

2	To study flow lines in a given forged sample	2
3	To study the microstructure and volume of different phases in the given metallic sample using optical microscope	2
4	To study the fracture surface of metal specimens using SEM.	1
5	Chemical analysis using energy dispersive energy dispersive analysis in SEM (spot and line analysis)	1
6.	Determination of phases in multiphase powder sample using XRD.	1
7.	Determine the hardness of a given metallic specimen using different hardness testing methods	2
8.	To perform Tensile and compression testing on materials	1
9.	To study the Ultrasonic Flow Detector and examine the given sample	1
10.	To study and perform Fatigue Test	1
11.	To study the DSC/DTA analysis of given sample.	1

Course Outcomes:
Students will be able to

1. Explain the principles, instrumentation, and limitations of various characterization and testing techniques (XRD, optical microscopy, SEM/TEM, FTIR, UV-Vis, XRF, and NDT etc.) used for materials analysis.
2. Select and justify the most appropriate combination of characterization and testing techniques for a given material problem to determine the composition, structure, properties and performance of materials.
3. Interpret and correlate data obtained from microscopy, spectroscopy, diffraction, mechanical testing, and thermal analysis techniques to establish structure–property relationships.
4. Design a comprehensive characterization plan for a given material system by selecting appropriate techniques, defining experimental sequence and specifying necessary sample preparation steps.

Text Book

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Qualitative and Quantitative Analysis/Alexive/MIR Publisher	1982

Reference Books

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Testing of Materials/Davis and Troxell/McGraw-Hill	1998
2	X-ray Diffraction/B D Cullity/Addison-Wesley	1956
3	Chemical and Metallurgical Analysis/ Vogel/Longman Scientific and Technical	1999
4	Mechanical Metallurgy/Dieter/McGraw-Hill	2009
5	Principles of Physical Metallurgy/R.E. Reed-Hill/ McGraw-Hill	2008

Equivalent MOOCs

Sr. No.	Course Links	Offered by
1	Material Characterization https://nptel.ac.in/courses/113106034	NPTEL
2	Characterization of Materials https://nptel.ac.in/courses/115103030	NPTEL

CO-PO-PSO Mapping Matrix (MMN 504 Materials Characterization and Testing)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	-	-	1	-	-	-	-	-	-	2	3
CO2	3	3	1	1	2	-	-	-	-	-	-	2	3
CO3	2	3	3	2	2	-	1	-	2	-	1	3	3
CO4	3	3	2	2	-	-	-	-	-	-	-	2	3

Course Name	**:**	**Materials Characterization and Testing**
Course Code	**:**	**MMM 103**
Credits	**:**	**04**
L T P	**:**	**3 0 2**

Course Objectives:
• To understand the fundamental concepts of different characterization methods. • To analyze characterization methods for the determination of the result of composition, structure, and properties of materials. • To integrate multiple techniques for comprehensive material analysis, enabling a holistic understanding of materials' properties. • Acquire proficiency in data analysis, pattern recognition, and interpretation specific to each technique

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**Macroscopic Examination** Introduction, Importance & scope of Macro etching, Sulphur/Phosphorus/Oxide Printing, Flow Lines	3
Unit 2	**Microscopic Examination** Preparation, and etching of Specimens of metals & alloys, Principle, Construction & working of metallurgical microscope, Optical Microscope and its types, Defects in lenses & their remedies, Applications: Phase identification, grain size measurement etc.,	6
Unit 3	**Spectroscopic Analysis** Introduction to spectroscopy, FTIR and UV-Vis spectroscopy and X-ray Fluorescence (XRF). Applications of spectroscopy	4
Unit 4	**Electron Microscopy** Scanning Electron Microscope (SEM): Principle, construction, and working of SEM, Interaction of electron beam with the specimen, Study of fractured surfaces, Energy and wavelength dispersive spectroscopy, Introduction to Transmission Electron Microscopy (TEM)	6
Unit 5	**X-Ray Diffraction** Bragg's condition of diffraction, X-ray scattering, application of X-ray diffraction- phase identification, estimation of crystallite size, residual stress,	5
Unit 6	**Mechanical Testing** Tensile testing, Hardness testing: Brinell, Rockwell and Brinell hardness, Impact testing: Charpy and Izod testing SN curve testing and crack growth, wear and friction testing: dry sliding wear test, Pin on disc test, and Nano-indentation.	7
Unit 7	**Non-Destructive Testing** X-ray/Gamma-ray radiography, Ultrasonic testing, Magnetic methods- Magnetic particle test/Magna Flux, Zyglo/Die penetration test, Eddy current test.	6
Unit 8	**Thermal Analysis** Principles of Differential Scanning Calorimetry (DSC), Differential Mechanical Thermal Analysis (DMTA), Dilatometry, and Thermogravimetric Analysis (TGA)	5

List of Experiments:		**Number of Turns**
1	To study the segregation of sulfur and phosphorus by sulfur printing and phosphorus printing.	1
2	To study flow lines in a given forged sample	2

3	To study the microstructure and volume of different phases in the given metallic sample using optical microscope	2
4	To study the fracture surface of metal specimens using SEM.	1
5	Chemical analysis using energy dispersive energy dispersive analysis in SEM (spot and line analysis)	1
6.	Determination of phases in multiphase powder sample using XRD.	1
7.	Determine the hardness of a given metallic specimen using different hardness testing methods	2
8.	To perform Tensile and compression testing on materials	1
9.	To study the Ultrasonic Flow Detector and examine the given sample	1
10.	To study and perform Fatigue Test	1
11.	To study the DSC/DTA analysis of given sample.	1

Course Outcomes:
Students will be able:

1. Explain the principles, instrumentation, and limitations of various characterization and testing techniques (XRD, optical microscopy, SEM/TEM, FTIR, UV-Vis, XRF, and NDT etc.) used for materials analysis.
2. Select and justify the most appropriate combination of characterization and testing techniques for a given material problem to determine the composition, structure, properties and performance of materials.
3. Interpret and correlate data obtained from microscopy, spectroscopy, diffraction, mechanical testing, and thermal analysis techniques to establish structure–property relationships.
4. Design a comprehensive characterization plan for a given material system by selecting appropriate techniques, defining experimental sequence and specifying necessary sample preparation steps.

Text Book

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Qualitative and Quantitative Analysis/Alexive/MIR Publisher	1982

Reference Books

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Testing of Materials/Davis and Troxell/McGraw-Hill	1998
2	X-ray Diffraction/B D Cullity/Addison-Wesley	1956
3	Chemical and Metallurgical Analysis/ Vogel/Longman Scientific and Technical	1999
4	Mechanical Metallurgy/Dieter/McGraw-Hill	2009
5	Principles of Physical Metallurgy/R.E. Reed-Hill/ McGraw-Hill	2008

Equivalent MOOCs

Sr. No.	Course Links	Offered by
1	Material Characterization https://nptel.ac.in/courses/113106034	NPTEL
2	Characterization of Materials https://nptel.ac.in/courses/115103030	NPTEL

CO-PO-PSO Mapping Matrix (MMM 103 Materials Characterization and Testing)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	-	-	1	-	-	-	-	-	-	2	3
CO2	3	3	1	1	2	-	-	-	-	-	-	2	3
CO3	2	3	3	2	2	-	1	-	2	-	1	3	3
CO4	3	3	2	2	-	-	-	-	-	-	-	2	3

Course Name	**:**	**Polymers for Industrial Applications**
Course Code	**:**	**MME 105**
Credits	**:**	**4**
L T P	**:**	**3 1 0**

Course Objectives:
Students should be able - • To analyze the structural properties of polymers for industrial applications. • To explore the vast potential of polymers in industrial applications. • To apply polymers effectively to optimize their physical and chemical properties. • To develop advanced polymer materials for industrial application. • To enable sustainable practices in various industries, the adoption of biodegradable and eco- friendly polymers.

Total No. of Lectures – 42

Lecture Wise Breakup		**No. of Lectures**
Unit 1	**Introduction** Basic concept, classification, chemical bonding and molecular forces in polymers, thermoplastics and thermosets, molecular weight and its distribution determination (M_n to M_z), free radical polymerization, Ziegler-Natta polymerization, cationic & anionic polymerization, novolacs and resol: effect of the ratio of phenol to aldehyde on the nature and the property of the polymer.	6
Unit 2	**Processing Technique** Compounding and vulcanization, molding techniques: extrusion, injection molding, blow molding, compression molding.	3
Unit 3	**Mechanical Properties** Stress-Strain behavior, effects of temperature on stress-strain behavior of polymer, macroscopic deformation, viscoelastic deformation, viscoelastic relaxation modulus, fracture of polymers, other mechanical properties, plastic deformation and its mechanism, deformation of elastomers.	6
Unit 4	**Thermal Properties** Heat capacity, transition temperatures such as T_g and T_m, heat capacity of crystalline and amorphous polymers, thermal conductivity, thermal analysis of polymers (DTA, DSC, and TGA).	6
Unit 5	**Polymer Charaterization** Polymer spectroscopy and compositional analysis, Infrared spectroscopy, Raman spectroscopy, Nuclear magnetic resonance	3
Unit 6	**Liquid Crystalline polymers** Introduction, history, structural requirements, types of liquid crystalline (LC) phases and liquid crystalline polymers, anisotropic properties. Applications of LC polymers-optical, high strength fibers, MEMS.	6
Unit 7	**Smart polymers and their applications** Theory of conduction, semi-conductors and conducting polymers, requirements for polymer to work as conductor, types of conducting polymers-intrinsic and extrinsic, doping of polymeric systems, synthesis, processing and testing of conducting polymers, applications and recent advances. Combustion of polymeric materials and methods to reduce it; requirements for heat resistance. Synthesis, structure-property relationships, fire retardant fillers, applications of heat resistant polymers like polyamides, polyimides and its derivatives. Introduction to smart polymers, temperature responsive polymers, pH responsive polymers, photo responsive polymers, magnetically responsive	6

	polymers, enzyme responsive polymers, shape memory polymers, hydrogels, self-healing polymers. Applications of smart polymers in various fields such as drug delivery, tissue engineering, medical devices, bio-separation, optical data storage, packaging and textiles etc.	
Unit 8	**Biopolymers and Biodegradable polymers** Study of biopolymers and their applications, like bioassays, biocatalysts, etc., need of biomaterials and biopolymers, biodegradation, overview of biodegradable polymers, degradation study, factor affecting biodegradability	3
Unit 9	**Miscellaneous Polymers** Macromolecules as catalysts, reactive polymers, luminescent polymers, ion conducting polymers, high performance fibers, dendritic polymers, inorganic polymers, ionic polymers, hydrogels.	3

Course Outcomes:
Students will be able to

1. Explain the classification, structure, bonding, polymerization mechanisms, and processing techniques of polymers used in industrial applications.
2. Analyze polymer characterization data and assess the suitability of conventional, liquid crystalline, conducting, and smart polymers for specific engineering applications.
3. Evaluate the influence of molecular structure, processing conditions, and microstructural features on the mechanical, thermal, and functional properties of polymers.
4. Select and propose appropriate polymeric materials, biodegradable polymers, or advanced polymer systems for industrial applications based on performance, sustainability, and application requirements.

Text Book

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publ./ Reprint
1	Polymer Science/ V.R. Gowarikar, N.S. Viswanathan & Jayadev Sreedhar/ New Age International Publishers/3rd edition.	2019

Reference Books

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publ./ Reprint
1	Text book of polymer Science/ Fred W. Billmeyer/ John Wiley and Sons/3rd edition/.	2007
2	Polymer Science and Technology/ R. O. Ebewele/ CRC press/ 3rd edition.	2000
3	Polymer Science and Technology / Fried Joel R/ PHI	2014

Equivalent MOOCs

Sr. No.	Course Links	Offered by
1	Polymers: concepts, properties, uses and sustainability https://archive.nptel.ac.in/courses/103/106/105106205/	NPTEL
2	Characterization of Polymers, Elastomers and Composites https://archive.nptel.ac.in/courses/103/105/103105219/	NPTEL

CO-PO-PSO Mapping Matrix (MME 105 Polymers for Industrial Applications)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	2	-	-	-	-	-	-	-	-	3	2
CO2	3	2	3	-	-		-	-	-	-	-	2	3
CO3	3	3	2	-	-	-	-	-	-	-	-	2	3
CO4	3	3	2	-	-	2	-	-	-	-	-	2	3

Course Name	**:**	**Nanomaterials: Recent Developments and New Directions**
Course Code	**:**	**MME 107**
Credits	**:**	**4**
L T P	**:**	**3 1 0**

Course Objectives:

Students should be able:

- To analyze nanoscale phenomena.
- To explore nanomaterial synthesis techniques.
- To apply nanomaterials in practical contexts.
- To develop tailored nanomaterial properties.
- To enable critical thinking in nanomaterials.

Total No. of Lectures: 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**Introduction** Properties of materials & nanomaterials, role of size in nanomaterials, Calculation of particle size and Surface to Volume ratio	6
Unit 2	**Surface Science of Nanomaterials** Atomic bonding, band structure, band structure in nanomaterials, Crystal structure, Surfaces of closed packed structures, Surface energy- Crystallographically preferred surfaces, Surface reconfiguration	6
Unit 3	**Nanomaterials Synthesis And Their Properties** Synthesis and preparation of Nano materials: Sol Gel processing, Micro emulsion synthesis, Hydrothermal, Solvo-thermal synthesis method, Microwave assisted synthesis, Bulk and nano composite materials, Organic-Inorganic hybrid Nano composites, Quantum dot (QDs) synthesis– Difference between bulk and nanomaterials.	9
Unit 4	**Nanomaterials Characterization Techniques** Diffraction analysis, X-ray diffraction, Powder diffraction, Lattice parameters, Structure analyses, Strain analyses,Phase identification, Particle size analyses using Scherer`s formula, X-ray photoelectron spectroscopy (XPS), Infra-red spectroscopy (IR), Rotational & Vibrational, UV-visible, Raman Spectroscopy, Photoluminescence (PL), Cathode luminescence (CL).	9
Unit 5	**Properties of Nanomaterials** Electrical Properties, Mechanical Properties, Optical Properties, Magnetic Properties, Thermal Properties, Physical Properties	6
Unit 6	**Applications of Nanotechnology** Nano electronics, Nanotechnology in Diagnostics, Applications of nanotechnology: Environmental, Agricultural and food processing-Nano technology for energy systems, Light-emitting diodes (LEDs), laser diodes, single-electron transistors, photonic crystals, photodetectors, memory devices etc.	6

Course Outcomes:

Students will be able to

1. Differentiate structure and, electrical, thermal, and physical properties of bulk and nanomaterials.
2. Analyze nanomaterial synthesis processes considering the requirements of high precision, purity, yield, and sustainability.
3. Select the appropriate material characterization techniques for evaluating the structural properties (XRD and IR spectroscopy) and electronic and optical properties (Photoluminescence, Cathodoluminescence, and UV–vis spectroscopy) of nanomaterials

Text Book		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publ./ Reprint**
1	Carl.C.Koch, "Nanostructured materials, processing, properties and applications, NFL publications.	2007
Reference Books		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publ./ Reprint**
2	T.J.Chung, P.M. Anderson, M.K.Wu and S.Hsieh, "Nanomechanics of materials and structures, Springer.	2006
3	Nanoparticles: From theory to applications, Schmidt.G, Wiley Weinheim	2004
4	Hand Book of Nanophase & Nanostructured materials, Zhong Lin Wang, (Vol. I &II), Springer	2002.

Equivalent MOOCs

Sr. No.	Course Links	Offered by
1	Nanomaterials and their Properties https://archive.nptel.ac.in/courses/113/104/113104102/	NPTEL
2	Nanostructures and Nanomaterials: Characterization and Properties **https://archive.nptel.ac.in/courses/118/104/118104008/**	NPTEL

CO-PO-PSO Mapping Matrix (MME 107 Nanomaterials: Recent Developments and New Directions)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	2	-	-	-	-	-	-	-	1	2	2
CO2	3	2	3	-	-	2	-	-	-	-	-	2	3
CO3	3	3	2	-	-	-	-	-	-	-	-	2	3

Course Name	**:**	**Ceramics and their Advanced Applications**
Course Code	**:**	**MME 108**
Credits	**:**	**4**
L T P	**:**	**3 1 0**

Course Objectives:
At the end of the course, students will be able to: • To understand the fundamentals (structure, properties and processing) of ceramic materials • Describe the basics of ceramic processing including sintering theory and grain growth. • Relate the basics properties of advanced ceramic materials with their structure. • To apply those fundamentals for selecting and developing ceramic materials for different engineering applications. • To appreciate its advantages and limitations of various ceramic materials.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**Introduction** Definition of Ceramics, Elementary crystallography, Ceramic microstructure, Traditional Versus advance ceramics.	3
Unit 2	**Powder preparation and shaping of ceramics** Physical methods (different techniques of grinding), Chemical routes - coprecipitation, Sol- gel, Hydrothermal, Combustion synthesis, high temperature reaction (solid state reaction), Powder pressing, Injection molding, Slip casting, Tape casting.	6
Unit 3	**Sintering of ceramics** Thermodynamics and kinetics of sintering, different mechanisms and development of microstructure (including microwave sintering). Novel techniques (SPS, Microwave)	4
Unit 4	**Properties and application of engineering ceramics** Rupture strength; fracture Toughness, Elastic Constants, Hardness, Creep, Wear, Coefficient of thermal expansion, Thermal Property, Electrical Property, Magnetic properties, Thermoelectric properties, Bio-medical applications of ceramic materials, ceramics for energy and environment technologies (fuel cell, lithium battery, gas sensor and catalytic support).	5
Unit 5	**Transparent ceramics and its industrial application** Transparency, Importance of transparent ceramics, Transparent ceramics materials (simple and complex oxides), Ceramic powder synthesis, Sintering and densification of transparent ceramics (vacuum sintering, hot pressure, hot isostatic pressure sintering), Application (Laser, lighting, scintillators, ceramics electro optic devices, optical systems (lens).	8
Unit 6	**Porous ceramics and its industrial application** Introduction, Methods and techniques for fabrication of porous ceramics, Classification of porous ceramics, ceramics foams, Application (biomedical, catalysis, sensor).	6
Unit 7	**Glass, glass-ceramics and its industrial application** Types of glasses, Structural theories of glass formation, Thermal analysis, Kinetic theories of glass formation (nucleation, crystal growth, general kinetic treatment of glass formation), Transport properties (fundamental of diffusion, ionic diffusion, ion exchange ionic conductivity, chemical durability), Mechanical properties (Elastic modulus, hardness, fracture strength, thermal shock), Optical properties, Compositions and properties of commercial glasses (vitreous silica, soda lime silica glasses, borosilicate glasses, glass fibers, television tube glasses, glass-ceramics), and Applications.	10

Course Outcomes: Students will be able to:
1. Explain the principles of ceramic powder synthesis, shaping methods, sintering mechanisms, and microstructural development in advanced ceramic materials. 2. Analyze the influence of alloy composition, processing parameters, densification technique, glass formation kinetics, transport phenomena, and microstructural characteristics on the mechanical, thermal, electrical, optical, and functional properties of ceramic materials. 3. Evaluate fracture toughness, elastic modulus, hardness, thermal expansion, glass transition temperature (T_g), nucleation and crystal growth kinetics in ceramic and glass materials.

Text Book		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publ./ Reprint**
1	Fundamental of Ceramics/ Michel W. Barsoum/ McGraw Hill International edition	2019
Reference Books		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publ./ Reprint**
1	Modern Ceramic Engineering/ David. W. Richerson, Mercel Dekker/ NY	2019
2	Ceramic Processing and Sintering/ M. N. Rahman, Mercel Dekker/ CRC Press	2017
3	Handbook of Advanced Ceramics/ S. Somiya/ Academic Press	2003
4	Modern ceramic engineering: Properties, processing and use in design by Richerson, W.David, M.Dekker.	2018

Equivalent MOOCs

Sr. No.	**Course Links**	**Offered by**
1	Ceramics for Strategic Applications https://nptel.ac.in/courses/113105015	NPTEL
2	Electroceramics https://nptel.ac.in/courses/113104006	NPTEL

CO-PO-PSO Mapping Matrix (MME 108 Ceramics and their Advanced Applications)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**
CO1	2	2	2	-	-	-	-	-	-	-	-	2	3
CO2	3	3	3	-	-	-	-	-	-	-	-	2	3
CO3	3	3	3	-	-	-	-	-	-	-	-	2	3

Course Name	**:**	**Surface Engineering**
Course Code	**:**	**MME 106**
Credits	**:**	**4**
LTP	**:**	**3 1 0**

Course Objectives:

All the end of this course, the student will be able to

- Develop an understanding of various surface modification techniques to improve the surface properties and to evaluate their properties.
- Provide a comprehensive overview of the latest developments in thin films.
- Develop competence and skills to select suitable thin film deposition techniques/surfaces.
- Modification methods for certain application industries.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**Introduction** Introduction to surface energy and surface roughness, Surface related properties: wettability Emissivity, reflectivity, Surface and subsurface zones, Role of surface on various engineering phenomena, technological properties of surfaces, need for modification of surfaces.	4
Unit 2	**Friction and Wear** The industrial significance of tribology, friction theories, rules of solid-solid contact, liquid mediated contact, measurement methods of friction, friction of metals and alloys, the friction of ceramics, friction of polymer, friction of solid lubricants Types of wear mechanism: adhesive wear, abrasive wear, fatigue wear, impact wear, corrosive wear, fretting wear, and wear debris, testing methods, and standards. Methods and strategies to minimize friction and wear	10
Unit 3	**Surface Modification Techniques** Mechanical Method: Burnishing and Shot peening, Thermal Methods: Flame and induction hardening, Laser and electron beam hardening, Diffusion based hardening processes	8
Unit 4	**Coatings** Dip, barrier and chemical conversion coatings, vacuum and controlled- atmosphere coating, Thermal Barrier coatings, Hydrophobic and hydrophilic coatings	7
Unit 5	**Synthesis and Characterization of Coatings** Physical vapor deposition, chemical vapor deposition, sputtering, epitaxial films, evaporation, sputtering, plasma nitriding, plasma-assisted CVD. Fundamentals of electroplating, electrodeposition from plating baths, electroless plating, other plating processes Optical methods for measuring film thickness; mechanical techniques for measuring film thickness; surface roughness measurement	10
Unit 6	**Case Studies** Tribology in gearbox, transmission and transfer case, tribology of internal combustion engines	3

Course Outcomes
Students will be able to: 1. Analyze the role of surface energy, surface roughness, and surface-subsurface zones in governing tribological, optical, and corrosion-related properties of engineering components, and justify why surface modification is needed for specific industrial applications 2. Evaluate the influence of surface engineering processes (mechanical, thermal, coating and thin film deposition) on microstructure, properties (mechanical and optical), and service performance of engineering materials and components. 3. Create improved coating or surface modification strategies based on the knowledge gained from real-world tribological case studies by identifying failure mechanisms, and assessing the adequacy of existing surface treatments.

Text and		
Sr. No.	**Name of Book/Authors/Publisher**	**Year of Publ. /Reprint**
1	Modern Surface Technology/ Friedrich-Wilhelm Bach, Andreas Laarmann, Thomas Wenz/Wiley-VCH	1982
Reference Books		
Sr. No.	**Name of Book/Authors/Publisher**	**Year of Publ. /Reprint**
1	Introduction to Tribology /Bharat Bhushan/John Wiley & Sons	1999
2	The Materials Science of Thin Films / M. Ohring / Academic Press /2nd edition.	2005

Equivalent MOOCs

Sr. No.	Course Links	Offered by
1	Fundamentals of Surface Engineering https://www.youtube.com/watch?v=DgXdDI5epIA&list=PLLy_2iUCG87AbUlGJ4visB4cGcPsldOq2	NPTEL
2	Technology of surface coating https://www.youtube.com/watch?v=tyKtUoQo9VM&list=PLbMVogVj5nJTnVBY4n36KHSPJsPDy38QS	NPTEL

CO-PO-PSO Mapping Matrix (MME 106 Surface Engineering)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	3	-	-	-	-	-	-	-	-	-	2	2
CO2	3	3	2	-	-	-	-	-	-	-	-	3	2
CO3	2	3	3	-	-	-	-	-	-	-	-	3	3

Course Name	**:**	**Light Alloys and Composite Materials**
Course Code	**:**	**MME 109**
Credits	**:**	**4**
L T P	**:**	**3 1 0**

Course Objectives:
Students should be able - • To implement concepts of materials science, physical metallurgy and phase transformations for developing composite systems. • To analyze effect of individual components, manufacturing processes, and design parameters on the properties of developed alloys and their composites • To analyze the engineering problems and develop the possible alloys or composite systems with desired performance characteristics

Total No. of Lectures –42

Lecture wise breakup		**No. of Lectures**
Unit 1	**Light Alloys** Introduction and comparison of physical characteristics of three important light alloys	3
Unit 2	**Aluminum Alloys** Pure and Commercial Aluminum; Binary Al Alloys: Phase diagrams, Structure, Properties and Applications; Ternary and quaternary Al Alloys: Phase diagrams, Structure, Properties and Applications;	6
Unit 3	**Magnesium Alloys** Alloying elements in magnesium alloys: Al, Zn, Mn, Ca, rare earth elements; Effect on microstructure, strengthening mechanisms and properties; Properties of Magnesium Alloy: mechanical properties like High vibration and damping capacity; high dimensional stability; ; Corrosion behaviour of Mg alloys ;Amorphous and crystalline Magnesium alloys; applications in aerospace, automotive, electronics, biomedical, hydrogen storage applications	7
Unit 4	**Titanium Alloys** Structure and properties of Titanium alloys; Beta Titanium alloys; Orthorhombic Titanium aluminide intermetallic alloys; Fatigue of Titanium alloys; Oxidation and protection of Titanium alloys; Applications: Aerospace; Medical; Dentistry; Automotive industry; Offshore applications	6
Unit 5	**Al metal matrix composites** Structure and properties of Al metal matrix composites; specific emphasis on the useful properties high specific strength and specific stiffness, high hardness and wear resistance, high thermal conductivity, high energy absorption and a damping capacity and low coefficients of friction and thermal expansion; Industrial and commercial applications in light weight designs; Challenges hindering their full potential	8
Unit 6	**Magnesium metal composites** Magnesium-Carbon composites in Hydrogen storage; Challenges in processing of Magnesium composites	6

Unit 7	**Titanium matrix composites** Discontinuously Reinforced Particulate Titanium Matrix Composites: Reinforcement Type and Configuration; properties, processing, characterization and heat treatment; static and wear properties; Fatigue properties; Impact Damage; Fracture Toughness; Application in Aerospace; Automotive and Biomedical field	6

Course Outcomes:

Students will be able to

1. Explain the classification, physical characteristics, phase relationships, microstructure, properties, and applications of light alloys, with emphasis on aluminum and magnesium alloy systems.
2. Interpret the structure–property relationships, strengthening mechanisms, fatigue behavior, corrosion/oxidation characteristics, and engineering applications of titanium alloys.
3. Analyze the microstructure and evaluate mechanical, thermal, wear, damping, and functional properties of aluminum and magnesium metal matrix composites for lightweight engineering applications.
4. Apply and analyze the reinforcement mechanisms, processing routes, characterization techniques for fracture, fatigue performance, and industrial applications of titanium matrix composites.

Text Book

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publ./ Reprint
1	Light Alloys, Ian Polmear, David St John, Jian-Feng Nie, Ma Qian, Fifth Edition	2017

Reference Book

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publ./ Reprint
1	An Introduction to Composite Materials, D.Hull and T.W.Clyne, Second Edition, Cambridge University Press	2008

Equivalent MOOCs

Sr. No.	Course Links	Offered by
1	Aluminium based Alloys and Metals Matrix Composites https://nptel.ac.in/courses/113106105	NPTEL
2	Introduction to Biomaterials https://nptel.ac.in/courses/113104009	NPTEL

CO-PO-PSO Mapping Matrix (MME 109 Light Alloys and Composite Materials)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	3	-	-	-	-	-	-	-	-	2	3
CO2	3	3	3	-	-	-	-	-	-	-	-	3	3
CO3	3	3	2	-	-	-	-	-	-	-	-	3	3
CO4	3	3	3	-	-	-	-	-	-	-	-	2	3

Course Name	**:**	**Non-conventional Energy Harvesting and Storage**
Course Code	**:**	**MME 110**
Credits	**:**	**4**
L T P	**:**	**3 1 0**

Course Objectives:
Students should be able – • To analyze non-conventional energy systems. • To explore innovative energy harvesting and storage methods. • To apply the principles of non-conventional energy systems to design and implement real-world problems or solutions. • To develop sustainable energy solutions.

Total No. of Lectures – 42

Lecture Wise Breakup		**No. of Lectures**
Unit 1	**Fundamentals of Photovoltaic** Introduction, first generation, second generation, third generation, doping, fermi level, p-n junction, p-n junction characteristics, photovoltaic effect, photovoltaic material, basic parameters of solar cell, I–V characteristics, fill factor (FF), maximum power (Pmax), solar cell efficiency (Zec), Cell Physics, Energy Bands, More about Electrons and Their Energy, Transport, Generation and Recombination,	6
Unit 2	**Solar Hydrogen Generation: Photocatalytic and Photoelectrochemical Methods** Basics about Solar Water Splitting, Photocatalyic Methods, Metal Oxides/Metal Oxynitrides/Metal Nitrides/Metal Phosphides, Metal Chalcogenides, Photoelectrochemical Methods, Photocathode for Water Reduction and Photoanode for Water Oxidation.	6
Unit 3	**Chemical Storage of Hydrogen Based on Metal Hydrides and Hydrocarbons** Basics on Hydrogen Storage of Metal Hydrides, Hydrogen Storage Characteristics of Metal Hydrides, Storage Capacities, Thermodynamics and Reversible Storage Capacity, Hydrogenation and Dehydrogenation Kinetics Cycling Stability, Activation, Different Metal Hydrides, Binary Metal Hydrides, Metal Alloy Hydrides, Complex Metal Hydrides, Improving Metal Hydride Performance, Hydrocarbons for Hydrogen Storage, Reaction between Carbon Atom and Hydrogen, Reaction between Solid Carbon and Hydrogen, Reaction between Carbon Dioxide and Hydrogen.	6
Unit 4	**Physical Storage of Hydrogen Using Nanostructured and Porous Materials** Physical Storage Using Nanostructures, Carbon Nanostructures, Other Nanostructures and Microstructures, Physical Storage Using Metal-Organic Frameworks, Clathrate Hydrates	6
Unit 5	**Hydrogen Utilization: Fuel Cells** Basics of Fuel Cells, The Rational Development of Fuel Cells, Work Principles of Fuel Cells, Operation of Fuel Cells, Types of Fuel Cells, Alkaline Fuel Cell (AFC), Proton Exchange Membrane Fuel Cell (PEMFC), Phosphoric Acid Fuel Cell (PAFC), Molten Carbonate Fuel Cell (MCFC) Solid Oxide Fuel Cell (SOFC), Catalysts for Oxygen Reduction Reaction of Fuel Cells, Pt-Based Catalysts, Nonnoble Metal Catalysts, Fuel Processing Applications of Fuel Cells	9
Unit 6	**Wind Energy** Introduction, Origin of Winds, Nature of Winds, Wind Turbine Siting, Major Applications of Wind Power, Basics of Fluid Mechanics, Wind Turbine Aerodynamics, Wind Turbine Types and their Construction, Wind Energy Conversion Systems (WECS), Wind–Diesel Hybrid System, Effects of Wind Speed and Grid Condition (System Integration), Wind Energy Storage, Environmental Aspects, Wind Energy Program in India.	9

Course Outcomes: Students will be able to
1. Explain the operating principles of photovoltaic devices and solar hydrogen generation systems, and determine solar cell performance parameters including I-V characteristics, maximum power and conversion efficiency. 2. Apply thermodynamic and kinetic principles to compare hydrogen storage materials, including metal hydrides, hydrocarbons, nanostructured materials and porous materials, based on storage capacity, reversibility, hydrogenation/dehydrogenation reactions, cycling stability and practical applicability. 3. Analyze different fuel cell technologies (proton exchange membrane, alkaline, molten carbonate, solid oxide etc.) based on efficiency, operating temperature, fuel requirements, catalyst requirements and application areas for hydrogen utilization. 4. Assess the suitability of photovoltaic, hydrogen and wind energy technologies for sustainable energy applications by considering performance, energy storage, environmental impact and resource utilization.

Text Book		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publ./ Reprint**
1	Non-Conventional Energy Resources/ B.H. Khan/ McGraw Hill Education (India) Private Limited/3rd edition.	2016
Reference Book		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publ./ Reprint**
1	Electrochemical Energy Advanced Materials and Technologies/ Jiang, San Ping Shen, Pei Kang Sun, Xueliang Wang, Chao-Yang Zhang, Jiujun / Wiley-ISTE/1st edition.	2015
2	Hydrogen Generation, Storage, and Utilization Jin Zhong Zhang Jinghong Li, Yat Li, Yiping Zhao Publisher, John Wiley & Sons	2014
3	Electrochemical Methods: Fundamentals and Applications/ Allen J Bard, Larry R Faulkner/ Wiley/ 2nd edition.	2000

Equivalent MOOCs

Sr. No.	**Course Links**	**Offered by**
1	Non-Conventional Energy Resources https://archive.nptel.ac.in/courses/121/106/121106014/#	NPTEL
2	Electric Vehicles and Renewable Energy https://archive.nptel.ac.in/courses/108/106/108106182/#	NPTEL

CO-PO-PSO Mapping Matrix (MME 110 Non-conventional Energy Harvesting and Storage)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	–	–	-	-	–	–	–	–	–	2	3
CO2	3	2	-	-	-	1	–	–	–	–	–	2	3
CO3	3	3	2	-	-	1	–	–	–	–	–	2	3
CO4	3	3	2	-	-	2	–	-	-	-	-	2	3

Course Name	**:**	**Advanced Materials Characterization**
Course Code	**:**	**MMO 102**
Credits	**:**	**4**
L T P	**:**	**3 0 2**

Course Objectives:
The main objectives of this course are: • To analyze advanced material characterization techniques • To explore the capabilities and limitations of advanced material characterization • To apply advanced material characterization methods • To develop expertise in data interpretation • To enable innovation in materials science and engineering

Total No. of Lectures: 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**X-ray Diffraction (XRD)** Bragg's Law, Constructive and Destructive, Interference of Waves, What is X-ray Diffraction, Detection of Diffracted X-rays by Photographic film, Bragg's Law and Diffraction, Basics of Crystallography, Indexing of Planes and Directions, Production of X-rays, Characteristic X-ray Lines, Specimen Preparation, Detection of Diffracted X-rays by a Diffractometer, XRD Pattern of NaCl Powder, Significance of Peak Shape in XRD, Peak Width-Full Width at Half Maximum, More Applications of XRD.	9
Unit 2	**Electron Microscopy** Scanning electron microscopy (SEM), Instrumentation, Electron beam-specimen interaction, Specimen preparation, Energy dispersive spectroscopy (EDS) in electron microscopes; Transmission electron microscopy (TEM)-Basics of TEM, Electron sources, Specimen preparation, Image modes, Image contrast.	9
Unit 3	**Atomic Force Microscopy** Principle: Atomic Force Microscopy, AFM Configuration, Force distance diagram, Modes of AFM, Static mode, Dynamic mode, AFM Instrumentation, AFM Tip, Limitation of AFM, Typical Applications.	7
Unit 4	**Spectroscopy** **X-Ray Photon Spectroscopy (XPS)** Working Principle and applications of X-Ray Photon Spectroscopy (XPS), Ultra Violet Photon Spectroscopy (UPS), Auger Electron Spectroscopy (AES), Atomic model and electron configuration, Chemical shift, Depth profiling, Instrumentation, Applications and Principles of vibrational spectroscopy. **Fourier transform infrared spectroscopy** Infrared absorption, Normal modes of vibration, Bond properties and absorption trend, factors affecting group frequency, A survey of the important functional groups with example. **Ultra-violet and Visible Absorption Spectroscopy** Definitions, Beer's Law and Quantitation, Deviations and limitations to Beer's Law, Instrumentation for UV-VIS spectroscopy, Components and designs, Methods and applications of UV Visible spectroscopy.	9
Unit 5	**Thermal Analysis** Principles, Instrumentation, Comparison and interpretation of TGA and DTG curves, TGA curves of mixtures, Factors affecting TGA curves, Applications of TGA; Differential Thermal Analysis (DTA) and Differential Scanning Calorimetry (DSC)-Principles, Instrumentation and quantitative aspects of DTA and DSC curves; Interpretation of DTA and	8

	DSC curve. Influence of atmosphere on DTA curves of a sample.	
List of Experiments:		**No. of Turns**
1	To perform Infrared Spectroscopy for ceramic and polymeric materials. Identify unknown compounds. Determination of the functional groups present in compound	3
2	(a) To perform thermal analysis using DSC for glass transition temperature, crystallization and melting temperature of a plastic. (b) Thermal analysis of polymer samples by TGA and DTA DSC.	3
3	(a) To study ferrous and non-ferrous samples using SEM/EDS. Specimen preparation for SEM for inorganic materials. (b) Chemical analysis using energy dispersive energy dispersive analysis in SEM (spot and line analysis).	3
4	To perform structural analysis using X-ray diffraction technique. Estimation of crystallite size using Scherrer formula.	3
5	UV-Vis analysis for Aspirin overdose.	2

Course Outcomes:
Students will be able to

1. Explain the working principles and operational mechanisms of advanced material characterization techniques based on the interactions of materials with X-rays, electrons, photons, and scanning probes.
2. Apply advanced material characterization techniques such as XRD, SEM, TEM, AFM, spectroscopy, and thermal analysis to determine the structure, composition, and properties of engineering materials.
3. Analyze and interpret characterization data obtained from different techniques to correlate material structure, composition, and properties, and compare their effectiveness for specific applications.
4. Evaluate and select appropriate characterization techniques or integrated characterization strategies for solving research and industrial materials engineering problems, considering material type, objectives, limitations, and expected outcomes.

Text Book		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publ./ Reprint**
1	Y. Leng, Materials Characterization-Introduction to Microscopic and Spectroscopic Methods, John Wiley & Sons (Asia).	2008
Reference Books		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publ./ Reprint**
1	Nanomaterial and Polymer Membranes Synthesis, Characterization, and Applications, Tawfik Abdo Saleh, Vinod Kumar Gupta,Elsevier	2016
2	Characterization of Nanophase materials , Wang.Z.L (ed), Wiley-VCH, New York	2000
3	Y.R. Sharma, Elementary Organic Spectroscopy: Principles and Chemical applications, S Chand Publication, India	2021

Equivalent MOOCs

Sr. No.	Course Links	Offered by
1	Techniques of Material Characterization https://archive.nptel.ac.in/courses/113/105/113105101/	NPTEL
2	Characterization of Construction Materials https://archive.nptel.ac.in/courses/105/106/105106200/	NPTEL

CO-PO-PSO Mapping Matrix (MMO 102 Advanced Materials Characterization)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	3	2	1	1	-	-	-	-	-	-	-	3
CO2	3	3	2	1	1	-	-	-	-	-	-	-	3
CO3	3	3	2	1	3	-	-	-	-	-	-	-	3
CO4	3	3	3	1	1	-	-	-	2	-	-	-	3

Course Name	**:**	**Nanomaterials Technology and Applications**
Course Code	**:**	**MMO 103**
Credits	**:**	**4**
L T P	**:**	**3 1 0**

Course Objectives:
Students should be able: • To analyze nanoscale phenomena. • To explore nanomaterial synthesis techniques. • To apply nanomaterials in practical contexts. • To develop tailored nanomaterial properties. • To enable critical thinking in nanomaterials.

Total No. of Lectures: 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**Science and Technology of Nanomaterials** Introduction to miniaturization, fundamentals of nanoscience and nanotechnology, size dependence of properties, bulk to nano transition, carbon nanostructures, quantum wells, quantum wires, and quantum dots, mechanical, electronic and optical properties at nano level, nanostructured materials.	10
Unit 2	**Synthesis of Nanopowders** Gas phase synthesis, plasma chemical technique, precipitation from colloidal solutions, coprecipitation and sol-gel method, thermal decomposition and reduction, milling and mechanical alloying, synthesis by detonation and electric explosion, ordering in non-stoichiometric compounds.	9
Unit 3	**Preparation of Bulk Nanomaterials** Compaction of nanopowders, Film and coating deposition, crystallization of amorphous alloys, Severe plastic deformation, disorder-order transformations.	8
Unit 4	**Characterization of Nanomaterials** X-ray diffraction, Scanning Electron Microscopy, Scanning tunneling microscopy, Electron microscopy, X-ray absorption spectroscopy, Photoelectron emission spectroscopy, particle size distribution by BET & DLS methods.	9
Unit 5	**Applications of Nanomaterials** Nanotubes, nanowires, and nanodevices applications such as: Light-emitting diodes (LEDs), laser diodes, single-electron transistors, photonic crystals, photodetectors, memory devices etc.	6

Course Outcomes: Students will be able to
1. Explain the unique mechanical, optical, and electronic properties of nanomaterials. 2. Analyze nanomaterial synthesis processes considering the requirements of precision, purity, yield, and sustainability. 3. Evaluate the appropriate characterization techniques for obtaining the structure (XRD), surface morphology (SEM and STM), and particle size distribution (BET and DLS) of nanomaterials.

Text Book		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publ./ Reprint**
1	Carl.C.Koch, "Nanostructured materials, processing, properties and applications, NFL publications.	2007
Reference Books		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publ./ Reprint**
1	T.J.Chung, P.M. Anderson, M.K.Wu and S.Hsieh, "Nanomechanics of materials and structures, Springer.	2006
2	Nanoparticles: From theory to applications, Schmidt.G, Wiley Weinheim	2004
3	Hand Book of Nanophase & Nanostructured materials, Zhong Lin Wang, (Vol. I &II), Springer	2002.

Equivalent MOOCs

Sr. No.	Course Links	Offered by
1	Nanomaterials and their Properties https://archive.nptel.ac.in/courses/113/104/113104102/	NPTEL
2	Nanostructures and Nanomaterials: Characterization and Properties **https://archive.nptel.ac.in/courses/118/104/118104008/**	NPTEL

CO-PO-PSO Mapping Matrix (MMO 103 Nanomaterials Technology and Applications)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	2	-	-	-	-	-	-	-	-	2	2
CO2	3	2	3	-	-	1	-	-	-	-	-	2	3
CO3	3	3	2	-	-	-	-	-	-	-	-	2	3

Course Name	**:**	**Materials for E-Mobility**
Course Code	**:**	**MMO 104**
Credits	**:**	**4**
L T P	**:**	**3 1 0**

Course Objectives:

Students should be able –

- Classify types of batteries and suggest appropriate technologies for EVs
- Establish structure - microstructure - electrical performance correlations for various components of a battery
- Classify various types of supercapacitors and fuel cell and select appropriate types for EVs
- Compare various rare earth and rare earth free magnet technologies for motor applications
- Analyze various materials for their use as structural materials and charging infrastructure in EVs.

Total No. Lectures: 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**Introduction to Electric Vehicle (EVs) Technology** Shift of automotive industry towards electrification, Economic and environmental advantages of EVs, Classification of EVs, Comparison with the IC Engine Technology, e-vehicles life cycle analysis and raw material availability, Economic considerations for batteries in e-vehicles, Value chain for electric car batteries, Concept of energy density and power density, Comparative study of energy and power density of various battery technologies, Critical materials for E-Mobility	8
Unit 2	**Li Ion Batteries for EVs** Structure of Li ion battery: electrolyte, cathode and anode active materials, binder and separator, Performance requirement of battery components, Electrolytes in Li-ion batteries: Synthesis, fabrication, microstructure investigation and determination of electrical properties, Chemistry of cathode and anode materials for Li-ion batteries, integration of cathode, anode and electrolyte, measurement of electrical properties of cells	7
Unit 3	**Battery Pack Manufacturing and Alternate Battery Technologies** Materials for sealing of batteries, Cell to battery pack manufacturing, electrical insulations in Battery packs, thermal management materials in battery packs, Tradeoffs between specific power, specific energy, performance, cost, life span and safety in principal Li-ion battery technologies, Recycling of battery materials, Looking beyond Li-ion batteries: Mg, Al and Fe ion batteries, pros and cons w.r.t. Li-ion batteries, Indian Scenario for Li and alternate battery materials	7
Unit 4	**Supercapacitors and Fuel Cells for EVs** Comparison with other storage technologies, Supercapacitors: principle, types and materials used, key electrical characterization techniques, Battery-supercapacitor hybrid arrangement Fuel Cells: principle(s), types and materials used, key electrical characterization techniques, Battery-fuel cell hybrid arrangement for e-vehicles, Concept of battery-biofuel hybrid arrangement	7
Unit 5	**Materials for Motors in EVs** Critical Metals for electric motors: Nd, Eu, Y, Tb, Dy; manufacturing of rare earth and rare-earth free magnets for electric motors, Comparative Study on magnetic properties of rare earth and rare-earth free magnets, Recycling of magnetic materials from motors in e-vehicles, Non magnetic motors: an emerging technology	7
Unit 6	**Structural and other Essential Materials for EV Ecosystem** Fibre reinforced composites, steels, Al etc. in EV manufacturing, Materials for charging infrastructure, Solar-EV hybrid systems, Sensor materials, Materials for communication and display systems	6

Course Outcomes:
Students will be able to: 1) Explain the functions and performance requirements of materials used in Li-ion batteries for electric vehicles 2) Calculate key performance parameters of electric vehicle batteries, including cell voltage, capacity, energy density and power density, and compare various battery chemistries based on these parameters. 3) Analyze the suitability of batteries, supercapacitors and fuel cells for different electric mobility applications based on performance, safety and operational requirements. 4) Evaluate the suitability of materials used in energy storage, energy conversion, electric drive systems and supporting infrastructure considering performance, resource availability, recyclability and environmental sustainability.

Text Book		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publ./ Reprint**
1	Battery Technology Crash Course: A Concise Introduction / S. Petrovic /Springer / 1st edition	2021
Reference Books		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publ./ Reprint**
1	Alternative fuels and advanced vehicle technologies for improved environmental performance: Towards zero carbon transportation /R. Folkson/ Woodhead Publishing/1st Edition	2014
2	Electric Vehicles: Modern Technologies and Trends/ N. Patel, A.K. Bhoi, S. Padmanabhan, J. Holm-Nielsen /Springer/1st Edition	2021
3	Electric Vehicles for Smart Cities: Trends, Challenges and Opportunities/E.A. Nananki/Elsevier/1st Edition	2021
4	Future Lithium Ion Batteries/A. Eftekhari/Royal Society of Chemistry/1st Edition	2019

Equivalent MOOCs: There is no equivalent MOOC available on Swayam/NPTEL platform. However, related MOOCs are listed below.

Sr. No.	Course Links	Offered by
1	Fundamentals of Electric Vehicles: Technology and Applications https://nptel.ac.in/courses/108106170	NPTEL
2	Electric Vehicles and Renewable Energy https://nptel.ac.in/courses/108106182	NPTEL

CO-PO-PSO Mapping Matrix (MMO 104 Materials for E-Mobility)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	1	-	-	-	-	-	-	-	-	-	2	2
CO2	3	2	-	-	-	-	-	-	-	-	-	2	2
CO3	3	3	-	-	-	2	-	-	-	-	-	2	2
CO4	3	3	-	-	-	2	-	-	-	-	-	2	2

Course Name	**:**	**Light Metals and Composites**
Course Code	**:**	**MMO 105**
Credits	**:**	**4**
L T P	**:**	**3 1 0**

Course Objectives:

Students should be able -

- To implement concepts of materials science, physical metallurgy and phase transformations for developing composite systems.
- To analyze effect of individual components, manufacturing processes, and design parameters on the properties of developed alloys and their composites
- To analyze the engineering problems and develop the possible alloys or composite systems with desired performance characteristics

Total No. of Lectures –42

Lecture wise breakup		**No. of Lectures**
Unit 1	**Introduction to Light Metals and Composite Materials** Importance of light metals and composite materials in various engineering applications e.g. automotive, aerospace, biomedical, electronic etc., Comparison with other engineering materials, Advantages and limitations of light metals and composite materials	3
Unit 2	**Aluminum Alloys** Pure and Commercial Aluminum; Binary Al Alloys: Phase diagrams, Structure, Properties and Applications; Ternary and quaternary Al Alloys: Phase diagrams, Structure, Properties and Applications;	6
Unit 3	**Magnesium Alloys** Alloying elements in magnesium alloys: Al, Zn, Mn, Ca, rare earth elements; Effect on microstructure, strengthening mechanisms and properties; Properties of Magnesium Alloy: mechanical properties like High vibration and damping capacity; high dimensional stability; Corrosion behaviour of Mg alloys ;Amorphous and crystalline Magnesium alloys; applications in aerospace, automotive, electronics, biomedical, hydrogen storage applications	7
Unit 4	**Titanium Alloys** Structure and properties of Titanium alloys; Beta Titanium alloys; Orthorhombic Titanium aluminide intermetallic alloys; Fatigue of Titanium alloys; Oxidation and protection of Titanium alloys; Applications: Aerospace; Medical; Dentistry; Automotive industry; Offshore applications	6
Unit 5	**Al metal matrix composites** Structure and properties of Al metal matrix composites; specific emphasis on the useful properties high specific strength and specific stiffness, high hardness and wear resistance, high thermal conductivity, high energy absorption and a damping capacity and low coefficients of friction and thermal expansion; Industrial and commercial applications in light weight designs; Challenges hindering their full potential	8
Unit 6	**Magnesium metal composites** Magnesium-Carbon composites in Hydrogen storage; Challenges in processing of Magnesium composites	6

Unit 7	**Titanium matrix composites** Discontinuously Reinforced Particulate Titanium Matrix Composites: Reinforcement Type and Configuration; properties, processing, characterization and heat treatment; static and wear properties; Fatigue properties; Impact Damage; Fracture Toughness; Application in Aerospace; Automotive and Biomedical field	6

Course Outcomes:
Students will be able to

1. Apply the concepts of alloying, phase transformations, and strengthening mechanisms to explain the microstructure and properties of light metals and composite materials.
2. Analyze the influence of alloy composition, processing routes, microstructure and reinforcement characteristics on the mechanical, physical and corrosion properties of aluminium, magnesium, and titanium alloys and their composites.
3. Evaluate density, specific strength, specific stiffness, fatigue behavior, and fracture toughness of magnesium alloys, aluminium matrix composites, and titanium matrix composites for engineering applications.

Text and

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publ./ Reprint
1	Light Alloys, Ian Polmear, David St John, Jian-Feng Nie, Ma Qian, Fifth Edition	2017

Reference Books

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publ./ Reprint
1	An Introduction to Composite Materials, D.Hull and T.W.Clyne, Second Edition, Cambridge University Press	2008

Equivalent MOOCs

Sr. No.	Course Links	Offered by
1	Aluminium based Alloys and Metals Matrix Composites https://nptel.ac.in/courses/113106105	NPTEL
2	Introduction to Biomaterials https://nptel.ac.in/courses/113104009	NPTEL

CO-PO-PSO Mapping Matrix (MMO 105 Light Metals and Composites)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	2	2	2	-	-	-	-	-	-	-	-	2	3
CO2	3	3	3	-	-	-	-	-	-	-	-	2	3
CO3	3	3	3	-	-	-	-	-	-	-	-	3	3

Course Name	**:**	**Transport Phenomena**
Course Code	**:**	**MME 101**
Credits	**:**	**4**
L T P	**:**	**3 1 0**

Course Objectives:
Students should be able – • Classify types of fluids and solve fluid flow problems • Distinguish between laminar and turbulent flows and apply them to metallurgical processes • Distinguish between modes of heat transfer and apply them in isolation or combination to materials processing • Establish applicable mode of mass transfer to metallurgical processes

Total No. Lectures: 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**Introduction to Fluid Flow** Types of fluid flow, Classification of fluids, viscosity of liquid metals, slags, gases, molten salts and polymers, Momentum balance, Flow of falling film, Fully developed flow between parallel plates, Equation of continuity and the momentum equation, Navier - Stoke's equation, Application of Navier - Stokes's equation: Flow over a plate, Flow in inlet of circular tubes, Creeping flow around a solid sphere, Stoke's law and its application to inclusion and gas bubble removal	7
Unit 2	**Turbulent and Complex Flows** Friction factors for flow in tubes, Experimental results for friction factor, Flow past submerged bodies, Flow through packed bed reactor, Flow through fluidized bed reactor, Energy balance applications in fluid flow, Bernoulli's theorem, Applications of Bernoulli's theorem: Flow through ladles, Flow measurements, Flow through piping networks	8
Unit 3	**Conduction Heat Transfer** Steady state thermal conduction - Fourier's law, Thermal Conductivity and thermal diffusivity, Critical thickness of insulation, Application of steady state conduction to heat transfer in furnaces, Unsteady state thermal conduction: systems without internal temperature gradient and systems with internal temperature gradient, Lumped heat capacity approach to systems without internal temperature gradient, systems with internal temperature gradient: finite, semi-infinite and infinite systems, Use of Heisler charts in quenching of metals and alloys	8
Unit 4	**Convective Heat Transfer** Concept of velocity and thermal boundary layer, natural and forced convection of metallic materials with different configurations, Significance of various dimensionless numbers in quenching and their explanation with dimensionless analysis – Buckingham π theorem, Convective heat transfer in various metallurgical systems and processes e.g. quenching, forging, packed bed reactor, fluidized bed reactor, Convective heat transfer in solidification of melts and application of Chvorinov's rule	6
Unit 5	**Radiative and Coupled Heat Transfer** Principles of radiation heat transfer, Terms in radiation, laws of radiation, Emissivity, Radiation heat transfer between black bodies, non - black bodies, concept of view factor, Radiation heat transfer in furnaces, Few real life examples wherein all the modes of heat transfer are operative e.g. operation of fuel cells, curing of thermosetting polymers, heat loss through human body etc.	7
Unit 6	**Mass Transfer** Difference between diffusion and mass transfer, Convective mass transfer – natural and forced convection, Overall mass balance, Concept of mass transfer coefficient, Interfacial mass transfer, Interfacial turbulence	6

Course Outcomes: Students will be able to
1) Explain the fundamental principles governing momentum, heat and mass transfer in metallurgical and materials processing systems, including fluid flow in ladles and reactors, heat transfer in furnaces, quenching and solidification in metallic and non-metallic systems 2) Apply governing equations, transport properties and dimensionless analysis to solve fluid flow, heat transfer and mass transfer problems associated with ladles, packed and fluidized beds, furnaces, quenching, solidification and interfacial transport processes. 3) Analyze the influence of momentum, heat and mass transfer mechanisms on velocity profiles and pressure drop in ladles and reactors, cooling and solidification behaviour during casting and heat treatments, and mass transfer across slag–metal and slag–gas interfaces. 4) Evaluate the effectiveness of flow conditions, heat transfer characteristics and mass transfer conditions in controlling inclusion removal, pressure drop and fluidization behaviour in reactors, cooling rates during quenching, solidification time during casting, and transport across slag–metal and slag–gas interfaces.

Text Book		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publ./ Reprint**
1	Transport Phenomena in Materials Processing / D.R. Poirier, G.H. Geiger /Springer International Publishers / 1st edition	2016
Reference Books		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publ./ Reprint**
1	Rate Processes in Metallurgy /A.K. Mohanty/ Prentice Hall India/3rd Reprint	2009
2	Fundamentals of Heat and Mass Transfer/ T.L. Bergman, A.S. Lavine, F.P. Incropera, D.P. Dewitt /John Wiley and Sons/7th Edition	2011
3	Engineering Flow and Heat Exchanges/O. Levenspeil/Springer/3rd Edition	2014
4	An Introduction to Transport Phenomena in Materials Processing/D.R. Gaskell, M.J.M. Krane/CRC Press/3rd Edition	2024

Equivalent MOOCs

Sr. No.	**Course Links**	**Offered by**
1	Transport Phenomena in Materials https://nptel.ac.in/courses/112106237	NPTEL
2	Transport Phenomena https://nptel.ac.in/courses/103105128	NPTEL

CO-PO-PSO Mapping Matrix (MME 101 Transport Phenomena)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**
CO1	3	2	-	-	-	-	-	-	-	-	-	2	2
CO2	3	2	-	-	-	-	-	-	-	-	-	2	2
CO3	3	3	-	-	-	1	-	-	-	-	-	2	2
CO4	3	3	-	-	-	2	-	-	-	-	-	2	2

Course Name	**:**	**Extractive Metallurgy: Rare Earth Metals**
Course Code	**:**	**MME 102**
Credits	**:**	**4**
L T P	**:**	**3 1 0**

Course Objectives:
Students should be able – • Provide in depth knowledge about the processes used to purify rare earth and their applications • Capable of research problem-solving. • Apply rare earth in Aerospace, Biomedical etc. for industry.

Total no of Lecture: 42

Lecture wise breakup		**No. of Lectures**
Unit1	**Introduction:** Introduction and overview, definition, atomic structures, processing and handling, history and trade of Rare Earth(RE); geological distribution, World and India Scenario of RE, application of rare earth (RE).	9
Unit 2	**Rare Earth elements:** Ore mineral, classification, physical and chemical properties, chromatographic techniques for analysis, deposit exploration, mining, chemical treatment, separation processes, bio-sorption, recycling, economic aspects.	13
Unit 3	**Extraction:** Extraction of RE from Monazite, Thermit process, Ion exchange process, solvent extraction, Calciothermic method, Electrolytic method	10
Unit 4	**Applications:** Role of rare earth elements in Aerospace, Electric vehicles, Computer sector etc.	10

Course Outcomes: Students will be able to
1. Explain the occurrence, classification, physicochemical properties, geological distribution and industrial significance of rare earth elements. 2. Apply the principles of mineral processing, chemical treatment, separation and extraction processes to recover and purify rare earth elements from their ores. 3. Analyze the influence of mineral characteristics and operating parameters such as temperature, reagent concentration and process conditions on the recovery, purity and economic feasibility of rare earth elements through different separation and extraction routes. 4. Evaluate different extraction, separation and recycling routes for rare earth elements considering recovery efficiency, product purity, economic feasibility and sustainability for aerospace, electric vehicles, electronic applications etc.

Text Book

Sr. No.	**Name of Book/Author/ Publisher**	**Year of Publ./Reprint**
1	Voncken, J.H.L., The Rare Earth Elements: An Introduction.	2016

Sr. No.	Name of Book/Author/ Publisher	Year of Publ./Reprint
1	Atwood, D. A., 2012, The Rare Earth Elements: Fundamentals and Applications, Wiley.	2012
2	Lauf, R.J., Introduction to Radioactive Minerals, Schiffer Publishing Ltd.	2008
3	L'Annunziata, M. F., Radioactivity: Introduction and History, From the Quantum to Quarks.	2016

Equivalent MOOCs: There are no equivalent MOOCs but related MOOCs are given below.

Sr. No.	Course Links	Offered by
1	Mineral Resources: Geology, Exploration, Economics and Environment https://nptel.ac.in/courses/105105170	NPTEL
2	Introduction to Mineral Processing https://nptel.ac.in/courses/105105171	NPTEL

CO-PO-PSO Mapping Matrix (MME 102 Extractive Metallurgy: Rare Earth Metals)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	-	-	-	-	-	-	-	-	-	2	3
CO2	3	2	-	-	-	-	-	-	-	-	-	2	3
CO3	3	3	-	-	-	1	-	-	-	-	-	2	3
CO4	3	3	-	-	-	2	-	-	-	-	-	2	3

Course Name	**:**	**Modeling and Simulations in Materials**
Course Code	**:**	**MME 111**
Credits	**:**	**4**
L T P	**:**	**3 0 2**

Course Objectives
Student should be able to: • Understand the theoretical basis of multiscale materials modeling from atomistic level to continuum macroscopic scale • Familiarize with software used by simulating case studies in metals and materials • Calculate the internal materials properties using simulations • Conduct basic modeling and simulations on different material types and compare them real world observations

Total No. of Lecture-42

Lecture wise Breakup		**No. of Lectures**
Unit 1	**Atomistic modeling:** Methods of atomistic modeling, Quantum modeling (DFT), Physical calculation of metals, Molecular dynamics, reactive potentials and chemical interactions	7
Unit 2	**Case studies in metals:** brittle fracture in ceramics, dislocation dynamics in metals	7
Unit 3	**Stochastic and Continuum modeling:** Monte Carlo methods, application to radiation shielding and inverse problems and diffusion using Matlab, fundamentals of FEM**,**	7
Unit 4	**Case studies:** vacancy mediated diffusion, internal residual stresses, stress concentrations factor determination	7
Unit 5	**Emerging trends in modeling:** Introductory hands on AI and machine learning in Materials Science, neutral network, machine learning, Calphad	7
Unit 6	**Case studies:** random self avoiding walk in polymers, microstructure prediction in metals	7

List of Experiments:		**No. of Turns**
1	Course instructor would conduct experiments based modelling and simulation softwares/tools pertaining to topics covered in theory syllabus.	14

Course Outcomes: Students will be able to
1. Apply atomistic, stochastic, and continuum modelling approaches to simulate physical and mechanical properties across different length scales. 2. Analyze the influence of defects, diffusion, stress distribution, microstructural evolution, and processing conditions on material behavior using computational tools. 3. Evaluate the suitability, accuracy, and limitations of different modelling and simulation techniques for predicting material properties and engineering performance. 4. Design computational models and simulation workflows for investigating materials behavior and solving engineering problems in metals, ceramics, and polymers.

Text Books		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publ./ Reprint**
1	Introduction to Computational Materials Science Fundamentals to Applications/Lesar/Cambridge University Press	2013
Reference Books		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publ./ Reprint**
2	MATLAB: A Practical Introduction to Programming and Problem Solving /Stormy, Attaway/Elsevier	2017
3	Numerical Modeling in Materials Science and Engineering/Rappaz, Bellet, Deville/Springer	2003
4	Monte Carlo Methods/ KPN Murthy/Universities Press	2004
5	Statistical Physics/ Lifshitz, E.M., and L.P. Pitaevskii./ Pergammon Press	1980
6	Statistical Thermodynamics/ Shrodinger, Edwin/ Dover	1989

Equivalent MOOCs

Sr. No.	Course Links	Offered by
1	Advanced Thermodynamics and Molecular simulations https://archive.nptel.ac.in/courses/103/107/103107208/	NPTEL
2	Finite element modelling of welding processes https://archive.nptel.ac.in/courses/112/103/112103299/	NPTEL

CO-PO-PSO Mapping Matrix (MME 111 Modeling and Simulations in Materials)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	–	–	-	-	–	–	–	–	–	2	2
CO2	3	3	-	2	-	-	–	–	–	–	–	2	2
CO3	2	3	2	2	-	-	–	–	–	–	–	3	3
CO4	2	3	2	3	-	-	–	-	-	-	-	3	3

Course Name	**:**	**Advanced Materials Characterization**
Course Code	**:**	**MME 112**
Credits	**:**	**4**
L T P	**:**	**3 0 2**

Course Objectives:
The main objectives of this course are: • To analyze advanced material characterization techniques • To explore the capabilities and limitations of advanced material characterization • To apply advanced material characterization methods • To develop expertise in data interpretation • To enable innovation in materials science and engineering

Total No. of Lectures: 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**X-ray Diffraction (XRD)** Bragg's Law, Constructive and Destructive, Interference of Waves, What is X-ray Diffraction, Detection of Diffracted X-rays by Photographic film, Bragg's Law and Diffraction, Basics of Crystallography, Indexing of Planes and Directions, Production of X-rays, Characteristic X-ray Lines, Specimen Preparation, Detection of Diffracted X-rays by a Diffractometer, XRD Pattern of NaCl Powder, Significance of Peak Shape in XRD, Peak Width-Full Width at Half Maximum, More Applications of XRD.	9
Unit 2	**Electron Microscopy** Scanning electron microscopy (SEM), Instrumentation, Electron beam-specimen interaction, Specimen preparation, Energy dispersive spectroscopy (EDS) in electron microscopes; Transmission electron microscopy (TEM)-Basics of TEM, Electron sources, Specimen preparation, Image modes, Image contrast.	9
Unit 3	**Atomic Force Microscopy** Principle: Atomic Force Microscopy, AFM Configuration, Force distance diagram, Modes of AFM, Static mode, Dynamic mode, AFM Instrumentation, AFM Tip, Limitation of AFM, Typical Applications.	7
Unit 4	**Spectroscopy** **X-Ray Photon Spectroscopy (XPS)** Working Principle and applications of X-Ray Photon Spectroscopy (XPS), Ultra Violet Photon Spectroscopy (UPS), Auger Electron Spectroscopy (AES), Atomic model and electron configuration, Chemical shift, Depth profiling, Instrumentation, Applications and Principles of vibrational spectroscopy. **Fourier transform infrared spectroscopy** Infrared absorption, Normal modes of vibration, Bond properties and absorption trend, factors affecting group frequency, A survey of the important functional groups with example. **Ultra-violet and Visible Absorption Spectroscopy** Definitions, Beer's Law and Quantitation, Deviations and limitations to Beer's Law, Instrumentation for UV-VIS spectroscopy, Components and designs, Methods and applications of UV Visible spectroscopy.	9
Unit 5	**Thermal Analysis** Principles, Instrumentation, Comparison and interpretation of TGA and DTG curves, TGA curves of mixtures, Factors affecting TGA curves, Applications of TGA; Differential Thermal Analysis (DTA) and Differential Scanning Calorimetry (DSC)-Principles, Instrumentation and quantitative aspects of DTA and DSC curves;	8

	Interpretation of DTA and DSC curve. Influence of atmosphere on DTA curves of a sample.	
List of Experiments:		**No. of Turns**
1	To perform Infrared Spectroscopy for ceramic and polymeric materials. Identify unknown compounds. Determination of the functional groups present in compound	3
2	(a) To perform thermal analysis using DSC for glass transition temperature, crystallization and melting temperature of a plastic. (b) Thermal analysis of polymer samples by TGA and DTA DSC.	3
3	(a) To study ferrous and non-ferrous samples using SEM/EDS. Specimen preparation for SEM for inorganic materials. (b) Chemical analysis using energy dispersive energy dispersive analysis in SEM (spot and line analysis).	3
4	To perform structural analysis using X-ray diffraction technique. Estimation of crystallite size using Scherrer formula.	3
5	UV-Vis analysis for Aspirin overdose.	2

Course Outcomes:

1. Explain the working principles and operational mechanisms of advanced material characterization techniques based on the interactions of materials with X-rays, electrons, photons, and scanning probes.
2. Apply advanced material characterization techniques such as XRD, SEM, TEM, AFM, spectroscopy, and thermal analysis to determine the structure, composition, and properties of engineering materials.
3. Analyze and interpret characterization data obtained from different techniques to correlate material structure, composition, and properties, and compare their effectiveness for specific applications.
4. Evaluate and select appropriate characterization techniques or integrated characterization strategies for solving research and industrial materials engineering problems, considering material type, objectives, limitations, and expected outcomes.

Text Book

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publ./ Reprint
1	Y. Leng, Materials Characterization-Introduction to Microscopic and Spectroscopic Methods, John Wiley & Sons (Asia).	2008

Reference Books

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publ./ Reprint
1	Nanomaterial and Polymer Membranes Synthesis, Characterization, and Applications, Tawfik Abdo Saleh, Vinod Kumar Gupta,Elsevier	2016
2	Characterization of Nanophase materials , Wang.Z.L (ed), Wiley-VCH, New York	2000
3	Y.R. Sharma, Elementary Organic Spectroscopy: Principles and Chemical applications, S Chand Publication, India	2021

Equivalent MOOCs

Sr. No.	Course Links	Offered by
1	Techniques of Material Characterization https://archive.nptel.ac.in/courses/113/105/113105101/	NPTEL
2	Characterization of Construction Materials https://archive.nptel.ac.in/courses/105/106/105106200/	NPTEL

CO-PO-PSO Mapping Matrix (MME 112 Advanced Materials Characterization)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	3	2	1	1	-	-	-	-	-	2	-	3
CO2	3	3	2	1	1	-	-	-	-	-	2	-	3
CO3	3	3	2	1	2	-	-	-	2	-	2	-	3
CO4	3	3	3	1	1	-	-	-	-	-	2	-	3

Course Name	**:**	**Failure Analysis of Metals and Alloys**
Course Code	**:**	**MME 113**
Credits	**:**	**4**
LTP	**:**	**3 0 2**

Course Objectives
At the end of this course the student will be able to: • Acquire fundamental understanding of the fracture of solid materials. • Develop detailed understanding of fracture mechanics, creep, and fatigue. • Acquire basic understanding of the techniques used to perform failure analysis. • Understand different aspects of mechanical and corrosion failure

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**Introduction to failure of metals** Basic reasons for the failure of metals, various types of theories of failure, Griffith theory, Linear elastic plastic fracture mechanism, Importance of failure prevention, Approach to failure analysis of materials, Tools for failure analysis	4
Unit 2	**Mechanical aspects of failure** Tensile test, Principal stresses, Stress concentration, Tri-axial Stress and Constraint, Plane Stress and Strain, Fracture of Tensile Samples, Effect of Strain Rate and Temperature, Crack Propagation, revision of Ductile and Brittle Fracture, Fracture Mechanics and Failure, Fatigue Loading, Creep Deformation	8
Unit 3	**Fracture Mechanisms and Microfractographic Features** Slip and Cleavage, Twinning, Cleavage Fracture Topography, Void Coalescence, Mixed Mechanism and Quasi cleavage Fracture, Tearing Topography Surface, Intergranular Separation, Fatigue Fracture Topography, High-Temperature Fracture Topography, Environmentally Assisted Fracture, Wear	8
Unit 4	**Fracture Modes and Macrofractographic Features** Tensile Overload, Torsion Overload, Bending Overload, Fatigue Fracture, Correlation of Micro- and Macro fractographic Features.	5
Unit 5	**Investigation of Engg. failure due to fatigue, corrosion, wear, creep, tension**	8
Unit 6	**Case studies** Failure analysis of light metal alloys components, at least one case study representing each failure mode i.e. fatigue, wear, over load, tension &bending etc.	5
Unit 7	**Quality assurance** A strong link to failure analysis, quality control concept, quality assurance.	4

List of Experiments:		**No. of Turns**
1	Course instructor would conduct experiments based on analysis of various components failed during their processing and use.	14

Course Outcome
Students will be able to: 1. Explain the fundamental concepts of metal failure, theories of fracture, failure analysis methodology and

the influence of stresses, strain conditions, mechanical testing and loading parameters on material failure.

2. Apply fracture mechanisms and analyze microfractographic features associated with ductile, brittle, fatigue, creep, wear, and environmentally assisted failures in engineering materials.
3. Interpret macrofractographic features and investigate engineering component failures caused by fatigue, corrosion, wear, creep, tension, and bending using systematic failure analysis techniques.
4. Evaluate engineering failure case studies and relate quality assurance and quality control practices to failure prevention and reliability improvement.

Text Book

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publ./ Reprint
1	Failure Analysis of Engineering Structures: Methodology and Case Histories/V Ramachandran, A C Raghuram, R V Krishnan, and S K Bhaumik /ASM International	2005

Reference Book

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publ./ Reprint
1	Handbook of Materials Failure Analysis with Case Studies from the Aerospace and Automotive Industries/Abdel Salam Hamdy Makhlouf, Mahmood Aliofkhazraei/ Elsevier	2016
2	Materials Science and Engineering an Introduction/William D. Callister, Jr., David G. Rethwish/Wiley	2018
3	Deformation and Fracture Mechanics of Engineering Materials/R W Hertzberg/ John Wiley & Sons.	1996
4	Failure analysis of engineering materials, Charlie R. Brooks, Ashok Choudhury, McGraw-Hill	2002

Equivalent MOOCs

Sr. No.	Course Links	Offered by
1	Failure analysis and prevention https://www.youtube.com/watch?v=LChOyRnlhxo&list=PLSGws_74K01-qpJYGi2Rfza6dELXzUF0E	NPTEL
2	Engineering Fracture Mechanics https://www.youtube.com/watch?v=-eBRqhfdGrU&list=PLA218B83235A4AD5C	NPTEL

CO-PO-PSO Mapping Matrix (MME 113 Failure Analysis of Metals and Alloys)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	-	-	-	-		-	-	-	-	2	3
CO2	3	3	-	-	-	-		-	-	-	-	3	3
CO3	3	2	-	-	-	-	-	-	-	-	-	2	3
CO4	3	3	2	-	-	-	-	-	-	-	-	3	3

Course Name	**:**	**Corrosion Engineering**
Course Code	**:**	**MMO 107**
Credits	**:**	**4**
L T P	**:**	**3 1 0**

Course Objectives:
At the end of this course, the student will be able to: • Understand the fundamental of degradation and corrosion of materials in various environments. • Solve corrosion problems and design corrosion protection mechanisms.

Total No. of Lectures –42

Lecture wise breakup		**No. of Lectures**
Unit 1	Importance and cost of corrosion, thermodynamics of corrosion, passivation, Pourbaix diagram, The mixed potential theory of corrosion and its application to understand the influence of oxidizers, effect of velocity of the medium	8
Unit 2	Mechanism of oxidation, Pilling-Bedworth Ratio for oxides, Oxidation resistant materials	3
Unit 3	The Principles of corrosion, The electrodes potential, electrochemical series, Galvanic Series, Galvanic corrosion: area relationship in both active and passive states of metals. Computation of corrosion rate.	4
Unit 4	Different forms of corrosion and their control viz., uniform corrosion, galvanic corrosion, selective leaching, crevice corrosion, filliform corrosion, pitting corrosion, intergranular corrosion, erosion corrosion, fretting damage, stress corrosion cracking, corrosion fatigue, hydrogen embrittlement and microbes induced corrosion.	8
Unit 5	Corrosion testing procedures: Salt spray method, ASTM Copper strip corrosion standards, Electrochemical Testing, Immersion Testing, Cyclic Testing, Accelerated testing, Crevice Corrosion testing, evaluation of environmentally assisted cracking, evaluating localized cracking,	8
Unit 6	Inhibitors: Principles, Mechanisms and Applications, Types of Inhibitors and Their uses, Case studies	3
Unit 7	Corrosion Control Methods: cathodic protection, anodic protection, materials selection, Corrosion control Case studies from aerospace, automobile, oil and gas, refinery, petrochemical, pharmaceutical, paper and pulp industries, nuclear and thermal power plant.	8

Course Outcomes: Students will be able to:
1. Explain the fundamental principles of corrosion, including thermodynamics, passivation, mixed potential theory, oxidation and electrochemical concepts governing corrosion processes. 2. Apply electrochemical principles, Pourbaix diagrams, galvanic series and corrosion rate calculations to predict the corrosion behaviour of ferrous and non-ferrous metals and alloys in aqueous and high-temperature environments. 3. Analyze uniform, galvanic, localized and environmentally assisted forms of corrosion by correlating material characteristics and service environments with degradation mechanisms, and interpret corrosion testing results to assess corrosion susceptibility.

4.	Evaluate the suitability of corrosion mitigation strategies, including inhibitors, cathodic protection, anodic protection and materials selection, for controlling corrosion in different industrial environments and service conditions.

Text Book

Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publ./ Reprint**
1	Corrosion Engineering / Fontana / Tata McGraw Hill/ 3rd edition	2008

Reference Books

Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publ./ Reprint**
1	An Introduction to Electrometallurgy/ Satya Narain, Rajendra Sharan / Standard PublishersDistributors/ 2nd edition	1991
2	Electrochemistry and Corrosion Science / Nestor Perez / Springer US/ 1st edition	2004
3	Fundamental Aspects of Electro Metallurgy / K. Popov, B. Grgur, S.S. Djokic / Springer US/1st edition	2013

Equivalent MOOCs

Sr. No.	**Course Links**	**Offered by**
1	Aqueous Corrosion and its Control https://nptel.ac.in/courses/113101098	NPTEL
2	Corrosion Protection Methods https://nptel.ac.in/courses/113104108	NPTEL

CO-PO-PSO Mapping Matrix (MMO 107 Corrosion Engineering)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**
CO1	3	2	-	-	-	-	-	-	-	-	-	2	2
CO2	3	2	-	-	-	-	-	-	-	-	-	2	2
CO3	3	3	-	-	-	1	-	-	-	-	-	2	2
CO4	3	3	-	-	-	2	-	-	-	-	-	2	2

Course Name	**:**	**Failure Analysis of Materials**
Course Code	**:**	**MMO 108**
Credits	**:**	**4**
LTP	**:**	**3 1 0**

Course Objectives
At the end of this course the student will be able to: • Acquire fundamental understanding of the fracture of solid materials. • Develop detailed understanding of fracture mechanics, creep, and fatigue. • Acquire basic understanding of the techniques used to perform failure analysis. • Understand different aspects of mechanical and corrosion failure

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**Introduction to Failure Analysis** Relevance of failure in various engineering applications e.g. automotive, aerospace, biomedical, heavy engineering etc., cost of failure, design considerations w.r.t. failure	3
Unit 2	**Failure of Metals** Basic reasons for the failure of metals, various types of theories of failure, Griffith theory, Linear elastic plastic fracture mechanism, Importance of failure prevention, Approach to failure analysis of materials, Tools for failure analysis	4
Unit 3	**Mechanical aspects of failure** Tensile test, Principal stresses, Stress concentration, Tri-axial Stress and Constraint, Plane Stress and Strain, Fracture of Tensile Samples, Effect of Strain Rate and Temperature, Crack Propagation, revision of Ductile and Brittle Fracture, Fracture Mechanics and Failure, Fatigue Loading, Creep Deformation	7
Unit 4	**Fracture Mechanisms and Microfractographic Features** Slip and Cleavage, Twinning, Cleavage Fracture Topography, Void Coalescence, Mixed Mechanism and Quasi cleavage Fracture, Tearing Topography Surface, Intergranular Separation, Fatigue Fracture Topography, High-Temperature Fracture Topography, Environmentally Assisted Fracture, Wear	7
Unit 5	**Fracture Modes and Macrofractographic Features** Tensile Overload, Torsion Overload, Bending Overload, Fatigue Fracture, Correlation of Micro- and Macro fractographic Features.	5
Unit 6	**Investigation of Engg. failure due to fatigue, corrosion, wear, creep, tension**	7
Unit 7	**Case studies** Failure analysis of light metal alloys components, at least one case study representing each failure mode i.e. fatigue, wear, over load, tension &bending etc.	5
Unit 8	**Quality assurance** A strong link to failure analysis, quality control concept, quality assurance.	4

Course Outcome Students will be able to
1. Explain the fundamental concepts of metal failure, theories of fracture, failure analysis methodology and the influence of stresses, strain conditions, mechanical testing and loading parameters on material failure. 2. Apply fracture mechanisms and analyze microfractographic features associated with ductile, brittle, fatigue, creep, wear, and environmentally assisted failures in engineering materials. 3. Interpret macrofractographic features and investigate engineering component failures caused by fatigue,

	corrosion, wear, creep, tension, and bending using systematic failure analysis techniques.
4.	Evaluate engineering failure case studies and relate quality assurance and quality control practices to failure prevention and reliability improvement.

Text and Reference Books:

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publ./ Reprint
1	Failure Analysis of Engineering Structures: Methodology and Case Histories/V Ramachandran, A C Raghuram, R V Krishnan, and S K Bhaumik /ASM International	2005

Reference Books

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publ./ Reprint
1	Handbook of Materials Failure Analysis with Case Studies from the Aerospace and Automotive Industries/Abdel Salam Hamdy Makhlouf, Mahmood Aliofkhazraei/ Elsevier	2016
2	Materials Science and Engineering an Introduction/William D. Callister, Jr., David G. Rethwish/Wiley	2018
3	Deformation and Fracture Mechanics of Engineering Materials/R W Hertzberg/ John Wiley & Sons.	1996
4	Failure analysis of engineering materials, Charlie R. Brooks, Ashok Choudhury, McGraw-Hill	2002

Equivalent MOOCs

Sr. No.	Course Links	Offered by
1	Failure analysis and prevention https://www.youtube.com/watch?v=LChOyRnlhxo&list=PLSGws_74K01-qpJYGi2Rfza6dELXzUF0E	NPTEL
2	Engineering Fracture Mechanics https://www.youtube.com/watch?v=-eBRqhfdGrU&list=PLA218B83235A4AD5C	NPTEL

CO-PO-PSO Mapping Matrix (MMO 108 Failure Analysis of Materials)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	3	-	-	-		-	-	-	-	2	3
CO2	3	3	3	-	-	-		-	-	-	-	3	3
CO3	3	2	3	-	-	-	-	-	-	-	-	2	3
CO4	3	3	3	-	-	-	-	-	-	-	-	3	3

Course Name	**:**	**Plasma Technology**
Course Code	**:**	**MME 103**
Credits	**:**	**4**
L T P	**:**	**3 1 0**

Course Objectives:

Students should be able –

- To explore the fourth state of matter, Plasma.
- To understand fundamental characteristics of plasma, various plasma generation methods, various applications of plasma technology in nanomaterial synthesis, e-waste, energy production and storage, medicine/health care, etc.
- To acquire comprehensive knowledge of how plasmas are utilized for different types of materials processing specially in nanotechnology and developing advanced materials

Total no of Lecture: 42

Lecture wise breakup		**No. of Lectures**
Unit1	**Introduction** The fourth state of matter, Plasmas in nature, Saha equation, Comparison between real gases and plasma, plasma examples. Plasma definition, Collective behavior, Plasma quasi neutrality, Concept of plasma temperature, Debye shielding, Plasma frequency, Criterion of plasma, Types of plasma, advantages, Properties of Plasma	6
Unit 2	**Plasma Production Techniques** DC discharges, Glow discharge, I-V characteristic of electrical discharge, Paschen curve, Arc discharge, Transferred and non-transferred arcs, RF discharge, Capacitively and inductively coupled plasmas, Microwave discharge, Vacuum arcs	8
Unit 3	**Plasma Melting, Cutting and welding** Arc plasma melting, Synthesis of nanomaterials (Al_2O_3 and SiC) by plasma reactor/furnace, Plasma cutting, Plasma Welding	8
Unit 4	**Plasma Sputtering Deposition Processes** Introduction of thin film coatings by plasma, Plasma-Enhanced Chemical Vapor Deposition (PECVD), Physical vapor deposition (PVD), Pulsed laser deposition (PLD), Plasma nitriding	10
Unit 5	**Industrial applications of plasma** Plasmas for sterilization, Plasma in semiconductor industry, Plasma waste processing of industrial waste, Plasma Processing of E-waste, Biomedical and health applications	10

Course Outcomes:

Students will be able to

1. Analyze fundamental plasma parameters (Debye length, plasma frequency, plasma temperature, quasi-neutrality, and Saha equation), and determine the conditions under which an ionized gas qualifies as a plasma for a given set of physical parameters.
2. Evaluate process parameters (arc power, plasma enthalpy, deposition rate, and ion flux) for plasma melting, cutting, welding, and thin film deposition processes, and interpret the effect of parameter

variation on the quality of the processed material or coating. 3. Design a plasma-based processing system for a specified industrial (E-waste processing, semiconductor and biomedical etc.) by selecting suitable plasma generation method and defining operating parameters (pressure, power, gas composition etc.).

Text Book		
Sr. No.	**Name of Book/Author/ Publisher**	**Year of Publ./Reprint**
1	Principles of Plasma Discharges and Materials Processing, M. A. Lieberman and A. J. Lichtenberg (John Wiley and Sons)	2005
Reference Books		
Sr. No.	**Name of Book/Author/ Publisher**	**Year of Publ./Reprint**
1	Introduction to Plasma Physics and Controlled Fusion, 3rd edition, Francis F. Chen	2018
2	Plasma Technology, B. Gross, B. Greyz and K. Miklossy,	1968
3	Fundamentals of Plasma Physics, J. A. Bittencourt,	2004
4	Handbook of Plasma Processing Technology: Fundamental, Etching, Deposition and Surface Interactions, S. M. Rossnagel, J. J. Cuomo, W. D. Westwood,	2004

Equivalent MOOCs

Sr. No.	Course Links	Offered by
1	Plasma Physics and Applications https://nptel.ac.in/courses/115107447	NPTEL
2	Plasma Physics: Fundamentals and Applications https://nptel.ac.in/courses/115102020	NPTEL

CO-PO-PSO Mapping Matrix (MME 103 Plasma Technology)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	3	-	-	-	-	-	-	-	-	-	2	2
CO2	3	3	2	-	-	-	-	-	-	-	-	3	3
CO3	2	3	3	-	-	2	-	-	-	-	1	3	2

Course Name	**:**	**High Entropy Alloys**
Course Code	**:**	**MME 104**
Credits	**:**	**4**
L T P	**:**	**3 1 0**

Course Objective
Students should be able – • To Grasp the fundamental concepts of HEAs, including their composition, properties, and unique characteristics in comparison to traditional alloy • To explore various methods for synthesizing HEAs, covering techniques like mechanical alloying, liquid alloying, and additive manufacturing. • Solve operational problems of different difficulty levels in HEAs. • To understand microstructure property relationship for various engineering application

Total No. of Lectures - 42

Lecture wise Breakup		**Number of Lectures**
Unit 1	**Origin of high entropy alloys** Introduction, The coming of alloys, Special alloys and composites.	3
Unit 2	**High-entropy alloys: basic concepts** Classification of phase diagrams and alloys systems, Hume-Rothery rules, Definition of HEAs, Composition notation, Four core effects of HAEs,	5
Unit 3	**Physical Metallurgy of high entropy alloys** Crystal Structures and Phase Transformation in HEAs, Defects and Defect Energies in HEAs, Basic Mechanism of Sluggish Diffusion	7
Unit 4	**Synthesis and Processing** Liquid metallurgy route (Arc melting), Additive manufacturing (direct laser fabrication (DLF), selective electron beam melting (SEBM), and selective laser melting (SLM)), Solid state processing route (mechanical alloying, spark plasma sintering	8
Unit 5	**Mechanical Metallurgy of high entropy alloys** Plastic Deformation in HEAs, Creep and Creep Mechanisms in HEAs Tension, Serration, Fatigue, Nanoindentation	6
Unit 6	**Functional Properties** Diffusion barrier properties, Electric properties, Thermal properties, Magnetic properties, Catalytic properties, Thermoelectric properties, Irradiation resistance.	7
Unit 7	**Potential Application and Prospects** High entropy superalloys, refractory high entropy alloys, application of HEAs in automobile industries, aerospace, hydrogen storage, etc.	6

Course Outcomes: Students will be able to
1. Explain the fundamental concepts of high entropy alloys, including alloy classification, phase formation and the influence of high configurational entropy, severe lattice distortion, sluggish diffusion and cocktail effects on phase stability, mechanical properties and high temperature degradation. 2. Apply principles of phase transformations, diffusion and Hume–Rothery rules to predict phase formation and microstructural evolution in high entropy alloys synthesized through arc melting and solid-state processing routes such as mechanical alloying and spark plasma sintering. 3. Analyze the influence of composition, microstructure and defects on mechanical properties of HEAs including tensile, fatigue and creep, irradiation resistance and functional properties such as electrical, thermal, magnetic etc. 4. Design high entropy alloy compositions and processing strategies based on phase stability, microstructural evolution and property requirements to achieve targeted structural and functional

performance for specific engineering applications (e.g. jet engine superheaters, ultra-light prosthetic implants, nuclear reactor cladding etc.

Text Book		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publ./ Reprint**
1	Materials and Process Selection for Engineering Design/ M M Farah/ CRC Press	2020
Reference Books		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publ./ Reprint**
1	Engineering Materials: Properties and selection / Kenneth G Budinski, Michael K. Budinski/ Prentice Hall	2009
2	Engineering Material Technology/James A Jacobs and Thomas F Kilduff/ Prentice Hall of India	2000
3	Selection and uses of materials/Charles, Crane and Furness/Butterworth Heinmann publisher	1997

Equivalent MOOCs:

Sr. No.	Course Links	Offered by
1	Advanced Metallurgical Thermodynamics https://nptel.ac.in/courses/113106031	NPTEL
2	Thermodynamics of Materials https://nptel.ac.in/courses/113106031	NPTEL

CO-PO-PSO Mapping Matrix (MME 104 High Entropy Alloys)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO2
CO1	3	2	-	-	-	-	-	-	-	-	-	2	3
CO2	3	2	1	-	-	-	-	-	-	-	-	2	3
CO3	3	3	2	-	-	-	-	-	-	-	-	2	3
CO4	3	3	3	-	-	2	-	-	-	-	-	2	3

Course Name	**:**	**Failure Analysis of Metals and Alloys**
Course Code	**:**	**MMO 101**
Credits	**:**	**4**
LTP	**:**	**3 0 2**

Course Objectives
At the end of this course the student will be able to: • Acquire fundamental understanding of the fracture of solid materials. • Develop detailed understanding of fracture mechanics, creep, and fatigue. • Acquire basic understanding of the techniques used to perform failure analysis. • Understand different aspects of mechanical and corrosion failure

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**Introduction to failure of metals** Basic reasons for the failure of metals, various types of theories of failure, Griffith theory, Linear elastic plastic fracture mechanism, Importance of failure prevention, Approach to failure analysis of materials, Tools for failure analysis	4
Unit 2	**Mechanical aspects of failure** Tensile test, Principal stresses, Stress concentration, Tri-axial Stress and Constraint, Plane Stress and Strain, Fracture of Tensile Samples, Effect of Strain Rate and Temperature, Crack Propagation, revision of Ductile and Brittle Fracture, Fracture Mechanics and Failure, Fatigue Loading, Creep Deformation	8
Unit 3	**Fracture Mechanisms and Microfractographic Features** Slip and Cleavage, Twinning, Cleavage Fracture Topography, Void Coalescence, Mixed Mechanism and Quasi cleavage Fracture, Tearing Topography Surface, Intergranular Separation, Fatigue Fracture Topography, High-Temperature Fracture Topography, Environmentally Assisted Fracture, Wear	8
Unit 4	**Fracture Modes and Macrofractographic Features** Tensile Overload, Torsion Overload, Bending Overload, Fatigue Fracture, Correlation of Micro- and Macro fractographic Features.	5
Unit 5	**Investigation of Engg. failure due to fatigue, corrosion, wear, creep, tension**	8
Unit 6	**Case studies** Failure analysis of light metal alloys components, at least one case study representing each failure mode i.e. fatigue, wear, over load, tension &bending etc.	5
Unit 7	**Quality assurance** A strong link to failure analysis, quality control concept, quality assurance.	4

List of Experiments:		**No. of Turns**
1	Course instructor would conduct experiments based on analysis of various components failed during their processing and use.	14

Course Outcome
Students will be able to: 1. Explain the fundamental concepts of metal failure, theories of fracture, failure analysis methodology and the influence of stresses, strain conditions, mechanical testing and loading parameters on material failure.

2. Apply fracture mechanisms and analyze microfractographic features associated with ductile, brittle, fatigue, creep, wear, and environmentally assisted failures in engineering materials. 3. Interpret macrofractographic features and investigate engineering component failures caused by fatigue, corrosion, wear, creep, tension, and bending using systematic failure analysis techniques. 4. Evaluate engineering failure case studies and relate quality assurance and quality control practices to failure prevention and reliability improvement.

Text Book		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publ./ Reprint**
1	Failure Analysis of Engineering Structures: Methodology and Case Histories/V Ramachandran, A C Raghuram, R V Krishnan, and S K Bhaumik /ASM International	2005
Reference Book		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publ./ Reprint**
1	Handbook of Materials Failure Analysis with Case Studies from the Aerospace and Automotive Industries/Abdel Salam Hamdy Makhlouf, Mahmood Aliofkhazraei/ Elsevier	2016
2	Materials Science and Engineering an Introduction/William D. Callister, Jr., David G. Rethwish/Wiley	2018
3	Deformation and Fracture Mechanics of Engineering Materials/R W Hertzberg/ John Wiley & Sons.	1996
4	Failure analysis of engineering materials, Charlie R. Brooks, Ashok Choudhury, McGraw-Hill	2002

Equivalent MOOCs

Sr. No.	**Course Links**	**Offered by**
1	Failure analysis and prevention https://www.youtube.com/watch?v=LChOyRnlhxo&list=PLSGws_74K01-qpJYGi2Rfza6dELXzUF0E	NPTEL
2	Engineering Fracture Mechanics https://www.youtube.com/watch?v=-eBRqhfdGrU&list=PLA218B83235A4AD5C	NPTEL

CO-PO-PSO Mapping Matrix (MMO 101 Failure Analysis of Metals and Alloys)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**
CO1	3	2	-	-	-	-		-	1	-	-	2	3
CO2	3	3	-	-	-	-		-	-	-	-	3	3
CO3	3	2	-	-	-	-	-	-	1	-	-	2	3
CO4	3	3	2	-	2	-	-	-	-	-	-	3	3

Course Name	**:**	**Advanced Materials Processing**
Course Code	**:**	**MMO 106**
Credits	**:**	**4**
L T P	**:**	**3 1 0**

Course Objectives

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

- Understand the fundamentals of dislocation theory and apply them to metal plasticity.
- Become familiar with metal forming techniques including rolling, extrusion, wire drawing, forging, pilgering, sheet metal forming, hydroforming, superplastic forming
- Understand, identify and analyze the microstructural evolution in hot and cold metal forming operations
- Learn and Understand the fundamentals of ceramic processing methods and characterization of prepared components for mechanical and physical properties
- Learn and Understand the fundamentals of Powder metal processing methods and characterization of prepared components for mechanical and physical properties
- Learn the fundamentals of Additive manufacturing of Polymers by 3D printing
- Learn the fundamentals of Additive manufacturing of metals, its scope and challenges

Total No. of Lecture-42

Lecture wise Breakup		**No. of Lectures**
Unit 1	**Introduction to Materials Processing** Relevance of materials processing in various industries – automotive, aerospace, biomedical, heavy engineering etc., Basis for selection of suitable materials processing technique, Suitability of various materials for diverse applications	6
Unit 2	**Metal Processing: Basics of plasticity** Yield criterion, dislocation plasticity, twinning induced plasticity, flow stress determination, strain rate effects, residual stress, thermomechanical processing and microstructural evolution, plastic instability and superplasticity, workability	6
Unit 3	**Metal forming techniques:** Introduction to rolling, extrusion, wire drawing, forging, pilgering, sheet metal forming, hydroforming, superplastic forming: calculation of forming load, analysis of rolling load and variables, rolling defects, extrusion equipment, deformation, friction and defects in extrusion, seamless pipe tubing, Rod and wire drawing, residual stress in rods, wires and tubes, Sheet metal forming, shearing and blanking, deep drawing, forming limit diagram, defects in parts	6
Unit 4	**Microstructural evolution in Thermomechanical processing:** Hot and cold working, microstructure evolution, Defects in TMP: form defects, surface defects, fracture related defects, strain localizations. Physical simulation of properties: tensile and compression testing, hot torsion tests, mixed strain path tests, typical formability tests	6
Unit 5	**Powder ceramic processing** Kroger-Vink notation, Ceramic Powder production, characterization, batch calculations, milling, compaction, liquid and solid phase sintering, post sintering processing - HIP and Heat treatments; physical and mechanical evaluation of formed P/M parts, density and porosity determination, flexure testing, XRD, applications and case studies	6
Unit 6	**Powder Metal Processing** Fe based Powder grades and nomenclature, Powder production, characterization, admixed and premixed powders, batch calculations, milling, compaction, liquid and solid phase sintering, environment control, post sintering processing - HIP and Heat	6

	treatments; metallurgical evaluation of formed P/M parts, density and porosity determination, TRS testing, applications and case studies,	
Unit 7	**Additive manufacturing** Introduction to additive manufacturing: CAD modeling, slicing, printing, advantages and limitations. Basics of polymer 3D printing, choice of polymers, defects in AM parts, their characterization and prevention. Liquid and solid AM. Metal AM-challenges and advantages, gas atomized powders and HIP treatment; corrosion fatigue and fracture behavior	6

Course Outcomes:
Students will be able to:

1. Explain the principles of plastic deformation, thermomechanical processing, powder metallurgy, ceramic processing, and additive manufacturing used for advanced materials fabrication.
2. Analyze the effect of processing parameters such as strain, strain rate, temperature, compaction pressure, sintering conditions, and printing variables on microstructural evolution and defect formation.
3. Evaluate density, porosity, flexural strength, transverse rupture strength (TRS), forming load, residual stresses, tensile, compressive, hot torsion and formability of processed components.

Text		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Mechanical Metallurgy / George E Dieter / McGraw Hill	1986
Reference Books		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
2	Ceramic Processing/ M.N. Rahaman/ CRC, Taylor and Francis	2017
3	MPIF Standard 35/MPIF USA	2021
4	Additive Manufacturing Technologies /Ian Gibson/ Springer	2021

Equivalent MOOCs

Sr. No.	**Course Links**	**Offered by**
1	Metal forming techniques https://archive.nptel.ac.in/courses/112/107/112107250/	NPTEL
2	Powder metallurgy https://archive.nptel.ac.in/courses/113/106/113106098/	NPTEL
3	Metal Additive manufacturing https://archive.nptel.ac.in/courses/112/104/112104312/	NPTEL

CO-PO-PSO Mapping Matrix (MMO 106 Advanced Materials Processing)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**
CO1	3	3	2	-	-	-	-	-	-	-	-	2	3
CO2	3	3	3	-	-	-	-	-	-	-	-	2	3
CO3	3	3	3	-	-	-	-	-	-	-	-	3	3