RAJIV GANDHI UNIVERSITY OF KNOWLEDGE TECHNOLOGIES
ANDHRA PRADESH

(NUZVID-RKVALLEY-SRIKAKULAM- ONGOLE CAMPUSES)

DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING

DRAFT COURSE STRUCTURE AND DETAILED SYLLABUS FOR THE B.TECH PROGRAM

IN

METALLURGICAL AND MATERIALS ENGINEERING

(BOARD OF STUDIES PROPOSED COPY)

General, Course structure, Semester-wise credit distribution

A. Definition of Credit:

1 Hour Lecture (L) per week	1 credit
1 Hour Tutorial (T) per week	1 credit
3 Hours Practical (Lab)/week	1.5 credits

B. Total number of credits:160

C. Minimum number of contact hours/weeks per semester: 15 weeks of teaching

a. For 1 credit course: 15 contact hours per semester
b. For 2 credit course: 30 contact hours per semester
c. For 3 credit course: 45 contact hours per semester
d. For 4 credit course: 60 contact hours per semester

D. Course code and definition, Abbreviations

Course code	Definitions
L	Lecture
T	Tutorial
P	Practical
BSC	Basic Science Course
PCC	Program Core Course
PEC	Program Elective Course
OEC	Open Elective Course
MC	Mandatory Courses
HSMC	Humanities and Social Sciences including Management Science Course
PROJ	Minor/Major Project
SI	Summer Internship

E. Structure of the Program

S.No	Course Type	Credits
1	Basic Science Courses	20
2	Engineering Science Courses	16
3	Humanities and Social Sciences including Management courses	10
4	Professional core courses	77
5	Professional Elective courses	12
6	Summer Internship + Project Work	11
7	Open Elective Courses	12
8	Mandatory Courses [Environmental Sciences, Indian Constitution, Gender sensitization, Indian Community Services]	2
	Total	**160**

F. Semester-wise Credits Distribution

1

	TOTAL	**E1-S1**	**E1-S2**	**E2-S1**	**E2-S2**	**E3-S1**	**E3-S2**	**E4-S1**	**E4-S2**
BSC	20	8.5	8.5	3	0	0	0	0	0
ESC	16	11.5	4.5	0	0	0	0	0	0
HSMC	8.5	2.5	0	0	0	1.5	1.5	3	0
PCC	77	0	9.5	19.5	18	20	10	0	0
PEC	12	0	0	0	0	0	3	6	3
OEC	12	0	0	0	3	0	0	3	6
MC	2	0	0	0	0	0	0	0	2
PROJECTS	10.5	0	0	0	0	0	2.5	4	4
SUMMER INTERNSHIP	2	0	0	0	0	0	2	0	0
	160	**22.5**	**22.5**	**22.5**	**21**	**21.5**	**19**	**16**	**15**

Total number of Mandatory Courses (MC): 03 (Indian Constitution, Environmental Science, Gender Sensitisation)

***Mandatory Induction Program completes before the start of First year Semester-I.**

Notations:

E1-S1: Engineering first year first semester

E1-S2: Engineering first year second semester

E2-S1: Engineering second year first semester

E2-S2: Engineering second year second semester

E3-S1: Engineering third year first semester

E3-S2: Engineering third year second semester

E4-S1: Engineering fourth year first semester

E4-S2: Engineering fourth year second semester

G. Structure of curriculum

Mandatory Induction Program - 3 weeks (before start of First Year Semester-I)

- Physical activity
- Creative Arts
- Universal Human Values
- Literary
- Proficiency Modules
- Lectures by Eminent people
- Visit to local areas
- Familiarization of Dept/Branch Innovations

I Year I Semester

S. No	Course Code	Course Category	Course Title	L	T	P	Credits
1	20MA1101	BSC	Differential Equations and Multivariable Calculus	3	1	0	4
2	20PY1103	BSC	Engineering Physics	2	1	0	3
3	20CE1114	ESC	Engineering Graphics and Computer Drafting	1	0	3	2.5
4	20ME1113	ESC	Engineering Mechanics	3	0	0	3
5	20CS1108	ESC	Programming and Data Structures	3	0	0	3
6	20EG1181	HSC	English Language Communication Skills Lab-I	1	0	3	2.5
7	20PY1183	BSC	Engineering Physics Laboratory	0	0	3	1.5
8	20CS1188	ESC	Programming and Data Structures Laboratory	0	0	3	1.5
9	20ME1186	ESC	Workshop Manufacturing Practices	0	0	3	1.5
			Total	**14**	**1**	**15**	**22.5**

I Year II Semester

S. No	Course Code	Course Category	Course Title	L	T	P	Credits
1	20MA1201	BSC	Mathematical Methods-II	3	1	0	4
2	20CY1204	BSC	Engineering Chemistry	3	0	0	3
3	20EE1209	ESC	Basic Electrical and Electronics Engineering	3	0	0	3
4	20MM1201	PCC	Materials Thermodynamics	3	1	0	4
5	20MM1202	PCC	Physical Metallurgy	3	1	0	4
6	20CY1284	BSC	Engineering Chemistry Laboratory	0	0	3	1.5
7	20EE1289	ESC	Basic Electrical & Electronics Engineering Laboratory	0	0	3	1.5
8	20MM1281	PCC	Physical Metallurgy and Metallography Laboratory	0	0	3	1.5
9	20HS1201	MC	Indian Constitution	2	0	0	0
			Total	**17**	**3**	**9**	**22.5**

S.No	Course Code	Course Category	Course Title	L	T	P	Credits
1	20MA2104	BSC	Transform Calculus	3	0	0	3
2	20MM2101	PCC	Mineral Processing and Extractive Metallurgy	3	1	0	4
3	20MM2102	PCC	Phase Transformations and Heat Treatment	3	1	0	4
4	20MM2103	PCC	Mechanical Behaviour and Testing of Materials	3	1	0	4
5	20MM2104	PCC	Engineering Polymers	3	0	0	3
6	20MM2181	PCC	Mineral Processing and Extractive Metallurgy Laboratory	0	0	3	1.5
7	20MM2182	PCC	Phase Transformations and Heat Treatment Laboratory	0	0	3	1.5
8	20MM2183	PCC	Mechanical Behaviour and Testing of Materials Laboratory	0	0	3	1.5
9	20BE2101	MC	Environmental Science	2	0	0	0
			Total	**17**	**3**	**9**	**22.5**

II Year I Semester

II Year II Semester

S. No	Course Code	Course Category	Course Title	L	T	P	Credit s
1	20MM2201	PCC	Transport Phenomena in Materials	3	0	0	3
2	20MM2202	PCC	Iron making Technology	3	0	0	3
3	20MM2203	PCC	Metal Forming	3	0	0	3
4	20MM2204	PCC	Corrosion Engineering	3	0	0	3
5	20MM2205	PCC	Science and Technology of Ceramics	3	0	0	3
6	20XX22XX	OEC	Open Elective Course - 1	3	0	0	3
7	20MM2281	PCC	Metal Forming Laboratory	0	0	3	1.5
8	20MM2282	PCC	Corrosion Engineering Laboratory	0	0	3	1.5
			Total	**18**	**0**	**9**	**21**

III Year I Semester

S. No	Course Code	Course Category	Course Title	L	T	P	Credits
1	20MM3101	PCC	Materials Characterization	3	1	0	4
2	20MM3102	PCC	Solidification Process and Casting	3	1	0	4
3	20MM3103	PCC	Non-Ferrous Extractive Metallurgy	3	0	0	3
4	20MM3104	PCC	Semiconductor Materials	3	0	0	3
5	20MM3105	PCC	Steel Making Technology	3	0	0	3
6	20MM3181	PCC	Materials Characterization Laboratory	0	0	3	1.5
7	20MM3182	PCC	Solidification Process and Casting Laboratory	0	0	3	1.5
8	20EG3182	HSC	English Language Communication Skills Lab-II	0	0	3	1.5
9		MC	Gender sensitization	2	0	0	0
			Total	**17**	**2**	**9**	**21.5**

III Year II Semester

S. No	Course Code	Course Category	Course Title	L	T	P	Credits
1	20MM3201	PCC	Metal Joining and Non-Destructive Testing	3	1	0	4
2	20MM3202	PCC	Computational Materials Engineering	3	0	0	3
3	20MM32XX	PEC	Professional Elective Course - 1	3	0	0	3
4	20MM3281	PCC	Metal Joining and Non-Destructive Testing Lab	0	0	3	1.5
5	20MM3282	PCC	Computational Materials Engineering Lab	0	0	3	1.5
6	20MM3291	PROJ	Minor Project	0	0	4	2
7	20EG3282	HSC	English Language Communication Skills Lab-III	0	0	3	1.5
			Total	**9**	**1**	**13**	**16.5**

S. No	Course Code	Course Category	Course Title	L	T	P	Credits
1	20MM3292	SI	Summer Internship (6-8 Weeks)	0	0	0	2.5

IV Year I Semester

S. No	Course Code	Course Category	Course Title	L	T	P	Credits
1	20BM4101	HSC	Managerial Economics & Financial Analysis	3	0	0	3
2	20MM4191	PROJ	Major Project -1	0	0	8	4
3	20MM41XX	PEC	Professional Elective Course – 2	3	0	0	3
4	20MM41XX	PEC	Professional Elective Course – 3	3	0	0	3
5	20YY41XX	OEC	Open Elective Course- 2	3	0	0	3
			Total	**12**	**0**	**8**	**16**

IV Year II Semester

S. No	Course Code	Course Category	Course Title	L	T	P	Credits
1	20MM4291	PROJ	Major Project – 2	0	0	8	4
2	20MM42XX	PEC	Professional Elective Course – 4	3	0	0	3
3	20YY42XX	OEC	Open Elective Course- 3	3	0	0	3
4	20YY42XX	OEC	Open Elective Course- 4	3	0	0	3
5	20HS4299	MC	Indian Community Services	0	0	0	2
			Total	**9**	**0**	**8**	**15**

List of Professional Elective Courses

Course Category	Course Code	Course Title	Credits
Professional Elective Course – 1			
PEC	20MM3203	Electronic and Magnetic Properties of Materials	3
PEC	20MM3204	Polymer Product design	3
PEC	20MM3205	Soft Materials	3
PEC	20MM3206	Advanced Materials and processes	3
PEC	20MM3207	Powder Metallurgy	3
PEC	20MM3208	Secondary Steel Making	3
Professional Elective Course – 2			
PEC	20MM4101	Foundations of Computational Materials Modelling	3
PEC	20MM4102	Nanomaterials – Synthesis and applications	3
PEC	20MM4103	Introduction to Crystallographic texture and related phenomenon	3
PEC	20MM4104	Surface Science and Engineering	3
PEC	20MM4105	Light Metals and Alloys	3
PEC	20MM4106	Melt Treatment in Casting	3
Professional Elective Course – 3			
PEC	20MM4107	Composite Materials	3
PEC	20MM4108	Finite element method in Materials Engineering	3
PEC	20MM4109	Ceramic coatings	3
PEC	20MM4110	Introduction to Crystal Elasticity and Crystal Plasticity	3
PEC	20MM4111	Super Alloys	3
PEC	20MM4112	Fuels Furnaces Refractories	3
Professional Elective Course – 4			
PEC	20MM4201	Thermo mechanical and Thermo Chemical processing	3
PEC	20MM4202	Nuclear Materials	3
PEC	20MM4203	Polymer blends and alloys	3
PEC	20MM4204	Welding Metallurgy	3
PEC	20MM4205	Additive Manufacturing	3
PEC	20MM4206	Fracture Mechanics and Failure Analysis	3
Apart from the above listed subjects, any NPTEL/SWAYAM Course in related to Metallurgical and Materials Engineering can be offered as Professional Elective Course.			

List of Open Elective Courses

Open Elective Courses (POOL-A)

Course Category	Course Title	Credits
OEC	Biomaterials	3
OEC	Composite Materials	3
OEC	Diffusion in solids	3
OEC	Electron Microscopy	3
OEC	Energy Storage Materials	3
OEC	Nano materials	3
OEC	Nuclear Materials	3
OEC	Semiconductor Materials	3
OEC	Material Aspects in Design	3
OEC	Creep and Fatigue Behavior of Materials	3
Apart from the above listed subjects, any NPTEL/SWAYAM Course in related to Metallurgical and Materials Engineering can be offered as Open Elective Course.		

Open Elective Courses (POOL-B)

Course Category	Course Title	Credits
OEC	Biology for Engineers	3
OEC	Soft Skills and Interpersonal Communication	3
OEC	Economic Policies in India	3
OEC	Human Resource Development & Organization behaviour	3
OEC	Indian Music System	3
OEC	Intellectual Property Rights (IPR)	3
***At-least two courses must be taken from Open Elective Courses present in POOL-B**		

**** Completion of courses through MOOCs is subjected to the regulations and guidelines of the University/Institute from time to time.**

H. Minor Engineering programmes

Minor Course -1: Materials Science for Additive Manufacturing

S. No	Course Code	Course Category	Course Title	L	T	P	Credits
1	20MMM101	PCC	Science and Engineering of Materials	3	1	0	4
2	20MMM102	PCC	Additive Manufacturing Processes	3	0	0	3
3	20MMM103	PCC	Materials, Energy Sources and Bonding Mechanisms	3	0	0	3
4	20MMM104	PCC	Mechanical Behaviour and Testing of Materials	3	0	0	3
5	20MMM105	PCC	Materials Characterization	3	1	0	4
6	20MMM1XX	PEC	Professional Electives -1	3	0	0	3
			Total	**18**	**2**	**0**	**20**

Professional Elective Course – 1

Course Category	Course Code	Course Title	Credits
PEC	20MMM106	Science and Technology of Polymer	3
PEC	20MMM107	Powder Metallurgy	3
PEC	20MMM108	Nanomaterials – Synthesis and applications	3
PEC	20MMM109	Surface Science and Engineering	3
PEC	20MMM110	Composite Materials	3
PEC	20MMM111	Energy Storage Materials	3

Minor Course -2: Materials Testing

S. No	Course Code	Course Category	Course Title	L	T	P	Credits
1	20MMM201	PCC	Structure and Properties of Materials	3	0	0	3
2	20MMM202	PCC	Mechanical Testing of Materials	3	1	0	4
3	20MMM203	PCC	Non-Destructive Testing	3	0	0	3
4	20MMM204	PCC	Materials Characterization	3	1	0	4
5	20MMM205	PCCL	Materials Testing Laboratory-1	0	0	3	1.5
6	20MMM206	PCCL	Materials Testing Laboratory -2	0	0	3	1.5
7	20MMM2XX	PEC	Professional Electives -1	3	0	0	3
			Total	**15**	**2**	**6**	**20**

Professional Elective Course – 1			
CourseCategory	**CourseCode**	**Course Title**	**Cred its**
PEC	20MMM207	Advanced Characterization Techniques	3
PEC	20MMM208	Electron Microscopy	3
PEC	20MMM209	Modern Instrumental Methods of Analysis	3
PEC	20MMM210	Metallurgical Failure Analysis	3
PEC	20MMM211	Fracture Mechanics	3
PEC	20MMM213	Creep and Fatigue Behaviour of Materials	3

Minor Course -3: Materials Processing and Manufacturing

S. No	Course Code	Course Category	Course Title	L	T	P	Credits
1	20MMM301	PCC	Introduction to Materials Science and Engineering	3	1	0	4
2	20MMM302	PCC	Heat Treatment and Surface Engineering	3	0	0	3
3	20MMM303	PCC	Solidification Process and Casting	3	1	0	4
4	20MMM304	PCC	Metal Joining Technology	3	0	0	3
5	20MMM305	PCC	Metal Forming	3	0	0	3
6	20MMM306	PCC	Powder Metallurgy	3	0	0	3
			Total	**18**	**2**	**0**	**20**

Minor Course -4: Advanced Materials Technology

S. No	Course Code	Course Category	Course Title	L	T	P	Credits
1	20MMM401	PCC	Elements of Materials Science and Metallurgy	3	1	0	4
2	20MMM402	PCC	Advanced Materials and Processes	3	1	0	4
3	20MMM403	PCC	Advanced Ceramics and Glass	3	0	0	3
4	20MMM404	PCC	Nanomaterials Synthesis and Processing	3	0	0	3
5	20MMM405	PCC	Science and Technology of Composite Materials	3	0	0	3
6	20MMM406	PCC	Processing of Semi-Conducting Materials	3	0	0	3
			Total	**18**	**2**	**0**	**20**

Syllabus

Course Code	Course Name	Course Category	L-T-P	Credits
20MA1101	Differential Equations and Multivariable Calculus	BSC	3-1-0	4

Course Learning Objectives: The objective of this course is to

1. Discuss the Solutions of first order differential equations 2. Discuss the Solutions of higher order linear differential equations
3. Understand the converge of infinite series with different tests.
4. Learn power series representation of functions and its validity
5. Understand Continuity and differentiability of multi-variable functions and its applications to discuss maximum and minimum
6. Discuss the convergence Improper integrals and apply Leibnitz rule

Course Content:

Unit – I **(10 Contact hours)**

Differential equations of first order and first degree:

Basic concepts, Variable Separable method, homogeneous differential equations, Exact differential equations, Integrating factor, Differentiable equations Reducible to exact, Linear differential equations, Bernoulli differential equations.

Unit - II **(11 Contact hours)**

Linear differential equations of higher order:

Homogenous differentiable equations, Non-homogeneous linear equations of higher order with constant coefficients with RHS term of the type , , , polynomials in , ( ), ( ), Methods of Undetermined Coefficients, Method of variation of parameters, Euler Cauchy equation.

Unit - III **(12 Contact hours)**

Sequences and Series

Definition of Sequences and convergence, Convergence of series, Comparison test, Ratio test, Root test, Absolute and Conditional convergence, Alternating series, Power series, Taylor's and Maclaurin's series.

Unit - IV **(12 Contact hours)**

Functions of several variables:

Limit, Continuity and Differentiability of functions of several variables, Partial derivatives and their geometrical interpretation, Differentials, Derivatives of Composite and Implicit functions, Chain rule, Jacobians, Derivatives of higher order, Homogeneous functions, Euler's theorem, and Harmonic functions.

Unit - V

Applications of Functions of several Variable: (8 Contact hours) Taylor's expansion of functions of several variables, Maxima and Minima of functions of several variables - Lagrange's method of multipliers.

Unit – VI (6 Contact hours)

Beta and Gamma Function:
Beta and Gamma functions - elementary properties, Relation between Beta and gamma functions, Evaluation of Definite integral using Beta and Gamma functions, differentiation under integral sign, and differentiation of integrals with variable limits - Leibnitz rule.

Learning resources

Text book:
1. ERWIN KREYSZIG**, '***Advanced Engineering Mathematics'*, Wiley-India, 9th Edition

Reference Books:
1. TOM M. APOSTAL**,***' Calculus, Volume II'*, Wiley-India, Second Edition,
2. R. K. JAIN AND S. R. K. IYENGAR,' *Advanced Engineering Mathematics'*, Narosa Publishers, 3rd Edition.
3. B.S.GREWAL**, '***Higher Engineering Mathematics'*, Khanna Publishers, 42nd Edition.

Web resources:

1. NPTEL, IIT- Madras, 08-June-2017, Introduction to ordinary differential equations URL: https://nptel.ac.in/courses/111106100/12
2. NPTEL, IIT- Kanpur, 15-March-2016, Differential Calculus of Several Variables URL: https://nptel.ac.in/courses/111104092/11
3. NPTEL, IIT- Roorkee, 22-December-2017, Multivariable Calculus URL:https://nptel.ac.in/courses/111107108/
4. MatheMagician, 24–April-2017, Calculus - sequences and series, URL: https://www.youtube.com/playlist?list=PLJMXXdEk8kMAeBLj14HX0fhe_LypRc4aW
5.RGUKT Course Content

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

CO 1	Solve first order differential equations.
CO 2	Solve higher order linear differential equations.
CO 3	Check the convergence of infinite series with different methods
CO 4	Discuss the power series representation of a function at various points.

CO 5	Explain limits and continuity, differentiability and partial derivatives of functions of multivariable and solve the extremum problems subjected to constraints.
CO 6	Apply Leibnitz rule and beta gamma functions to evaluate improper integrals.

Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code	Course name	Course Category	L-T-P	Credits
20PY1103	Engineering Physics-MME	BSC	3-0-0	3

Course Learning Objectives:

1. To learn different optical phenomena shown by light waves related to interference, diffraction and polarisation.
2. To gain the basic knowledge of characteristics of coherent radiations and the basic knowledge in domain of Lasers, Optical fibers and its applications.
3. To gain the detailed knowledge in production of Ultrasonic waves and its applications.
4. To learn the detailed knowledge regarding the phenomenon of Thermal effects on Electricity.
5. To learn the detailed knowledge about Properties of Magnetic materials and its classifications.
6. To give knowledge about semiconductor physics and discus working and application of pn junction diodes.

Unit I: Wave Optics (8 Hours)

Introduction- Coherent sources- Interference in thin parallel film by reflection- Newton's rings- Fraunhofer diffraction due to single slit and multiple slits – Diffraction grating - Rayleigh criterion for resolving power- Resolving power of grating- Resolving power of Microscopes, Polarization- Brewster's law, Malus law, Double refraction- Half and Quarter wave plate.

UNIT-II: Laser and Fiber (8 Hours)

Lasers – principle and applications – Einstein's coefficients, Types of Lasers: three level lasers and four level lasers, Co_2 laser,Nd:YAG laser, - semiconductor lasers: construction and working – applications.

Optical fibres - classification (index & mode based) - principle and propagation of light in optical fibres - acceptance angle and numerical aperture - fibre optic communication system - active and passive sensors.

Unit III: Ultrasonics (8 Hours)

Introduction to ultrasonic waves, production – magnetostriction and piezoelectric methods - detection of ultrasound - acoustic grating – ultrasonic interferometer - industrial applications – Non-destructive testing - ultrasonic method: scan modes and practice.

Unit IV: Thermoelectricity (7 Hours)

Seebeck effect, thermoelectric power, thermoelectric series, Peltier effect, Thomoson effect, measurement of temperature using thermocouple, law of successive temperature, law of intermediate metal, application of thermodynamics to thermocouples.

Unit V: Magnetic Materials (7 Hours)

Concepts of magnetic dipole, magnetic moment, Magnetic quantities -types of magnetic materials: Dia, Para, ferro, antiferro and ferrimagnetic materials. Domain and Heisenberg exchange interaction theory-Hysteresis-hard and soft materials.

Unit VI: Semiconductors (7 Hours)

Formation of energy bands-Band theory of solids: metals, semiconductors and insulators (qualitatively)-intrinsicand extrinsic semiconductors- Fermi energy levels for doped, undoped semiconductors. Hall effect- Hall sensors. Physics of PN junction, solar cell and LED.

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

1. Students will be able to understand the phenomena of interference, diffraction and polarization exhibited by light waves.
2. Students will be able to understand the characteristics of lasers with an example and its application in specific to optic fiber. The principle and functioning of a few types of lasers: Solid, Gas & semiconductor and core properties of Optical fibers.
3. Students will acquire knowledge on production and application of ultrasonic waves in field of engineering.
4. Student will learn the physics behind the energy harvesting through the concept of thermo electric effects: Seebeck, Peltier and Thomoson in detailed manner.
5. Student will learn concept of magnetism and different Properties exhibited by all Magnetic materials.
6. Students will achieve the ability to explain the basic properties of semiconductors including the band gap and describe the working and design considerations for the various photonic devices like, solar-cells and LEDs

Learning resources

TEXT BOOKS

1.Md. N. Khan, S. Panigrahi, '*Principles of Engineering Physics 1*' Cambridge University press 2016

2.Dr. M.N Avadhanulu, Dr. P.G shirsagar '*A Textbook of Engineering Physics'* S.Chand Publications, 2014

3.M.A. Wahab, '*Solid State Physics: Structure and Properties of Materials',* Narosa Publications, 3rd Edition

REFERENCES

1. Gaur and Gupta 'Engineering Physics', Dhanpathrai Publications,1st edition
2. Hitendra K. Malik and A.K. Singh 'Engineering Physics' , 3 August 2017
3. Sear's and Zemansky 'University Physics', Pearson Publications, 8th Edition.
4. Serway, Jetwett, 'Physics for Scientists and Engineers with Modern Physics' Pearson Publications, 8th Edition

Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20CE1114	**Engineering Graphics and Computer Drafting**	**ESC**	**1-0-3**	**2.5**

Course Objectives:

1. To know about emergence of Engineering Graphics as a refined communication tool and to be aware of International and national standards of practice for uniform presentation of drawings.
2. To adopt the projection of three dimensional object orthogonally on a set of vertical and horizontal planes and obtain the views of the frontal and the top surfaces.
3. To describe the position of a point and position of the line with respect to all the planes of projection and obtain its views.
4. To learn orthographic projections of various simple plane surfaces in simple and inclined positions.
5. To know about orthographic projections of right and regular solids in simple positions, when their axes are perpendicular to one reference plane and parallel to the other.
6. To learn about types of cutting planes and to obtain views of simple solids.
7. To learn about different methodologies to be used for obtaining the two dimensional layout of the lateral surfaces of uncut solids.
8. To learn about computer aided drafting techniques and to be familiarize with one of the most powerful software 'AutoCAD'

Course Content:

Unit 1 **(10 Hrs)**

Introduction to Engineering drawing – Tools and Standards, Geometric Constructions, Scales, Conics and Special Curves - ellipse, parabola, hyperbola, cycloids, Involutes.

Unit 2 **(10 Hrs)**

Introduction to Orthographic Projections, Projection of points - projection of straight lines (only first angle projection method) inclined to both the principal planes -determination of true lengths and true inclinations by rotating line method and traces –

Unit 3 **(10 Hrs)**

Projection of Planes (polygonal and circular surfaces) inclined to both the principal planes by rotating object method. Projections of Solids: cube, prism, pyramid, cylinder, cone and sphere.

Unit 4 **(10 Hrs)**

Sections of Solids - cube, prism, pyramid, cylinder, cone and sphere. Development of Surfaces – Parallel line method and Radial line method

Unit 5 **(10 Hrs)**

Computer Aided Design – Introduction to AutoCAD, Co-ordinate System (UCS) and their Commands, Basic Commands of Drawing and Editing, Dimensioning and Text.

Unit 6 **(10 Hrs)**

Drawing practice with AutoCAD – Creating 2D Drawings of Objects from Isometric views (Iso to Ortho), Creating Isometric views form Orthographic views (Ortho to Iso) and Introduction to 3D drawings

Learning resources

Text book:

1. N.D.Bhatt and V.M.Panchal, "Engineering Drawing", Charotar Publishing House, 50th Edition, 2010.
2. K.Venugopal and V.Prabhu Raja, "Engineering Graphics", New Age International (P)Limited,2008

Reference Books:

1. K.R.Gopalakrishna., "Engineering Drawing" (Vol I&II combined) SubhasStores, Bangalore, 2007
2. M.B.Shah and B.C.Rana, "Engineering Drawing", Pearson, 2nd Edition, 2009
3. K.V.Natarajan, "A text book of Engineering Graphics", 28th Edition, Dhanalakshmi Publishers, Chennai, 2015

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

1. Aware of International and national standards of practice. Draw orthographic projections of lines, planes and solids
2. Familiar with obtaining the views of the frontal and the top surfaces of an object
3. Know to use the different drawing instruments.
4. Aware of orthographic projections of right and regular solids in simple positions, when their axes are perpendicular to one reference plane and parallel to the other.
5. Understand the concepts of three dimensional views such as isometric, oblique projections.
6. Know about computer aided drafting techniques and will be familiar with one of the most powerful software 'AutoCAD'

Assessment Method

Assessment Tool	Monthly tests	End Semester Test	Total
Weightage (%)	40%	60%	100%

Course code	Course Name	Course Category	L-T-P	Credits
20ME1113	Engineering Mechanics	ESC	3-0-0	3

Course Objectives: The objectives of this course are to

1. Explain the resolution of a system of forces, compute their resultant and solve problems using equations of equilibrium.
2. Perform analysis of bodies lying on rough surfaces.
3. Locate the Centroid of a body and compute the area moment of inertia and mass moment of inertia of standard and composite sections.
4. Explain kinetics and kinematics of particles, projectiles, curvilinear motion, centroidal motion and plane motion of rigid bodies.
5. Understand the concept of dynamics of particles and analysis the motion of particle.
6. Explain the concepts of work-energy method and its applications to translation, rotation and plane motion and the concept of vibrations.

Course Contents:

Unit I:

Introduction to Engineering Mechanics - Force systems, Forces acting at a point, Moment of a force about a point and about an axis; couple moment; reduction of a force system to a force and a couple.Equilibrium of system of forces - Free body diagram; equations of equilibrium; problems in two and three dimensions; Analysis of plane trusses.

Unit II:

Friction: Types of friction, Limiting friction, Laws of Friction, Static and Dynamic Friction; Motion of Bodies, wedge friction, screw jack.

Unit III:

Centroid and Centre of Gravity: Centroid of Lines, Areas and Volumes from first principle, Centroid of composite sections; Centre of Gravity and its implications. – Theorem of Pappus.

Unit IV:

Area moment of inertia- Definition, Moment of inertia of plane sections from first principles, Theorems of moment of inertia, Moment of inertia of standard sections and composite sections; Product of Inertia, Parallel Axis Theorem, Perpendicular Axis Theorem.

Mass Moment of Inertia: Moment of Inertia of Masses - Transfer Formula for Mass Moments of Inertia – Mass moment of inertia of composite bodies.

Unit V:

Particle dynamics- Rectilinear motion; Plane curvilinear motion (rectangular, path, and polar coordinates). 3-D curvilinear motion; Relative and constrained motion; Newton's 2nd law (rectangular, path, and polar coordinates). Work-kinetic energy, power, potential energy.Impulse-momentum (linear, angular); Impact (Direct and oblique).

Unit VI:

Kinetics of Rigid Bodies -Basic terms, general principles in dynamics; Types of motion, Instantaneous centre of rotation in plane motion and simple problems; D'Alembert's principle and its applications in plane motion and connected bodies; Work Energy principle and its application in plane motion of connected bodies; Kinetics of rigid body rotation.

Text Books:

1. Beer and Johnston, *Vector Mechanics for Engineers Statics and Dynamics,* (9th edition) by, Tata McGraw Hill Publishing Company, New Delhi.

References

1. Tayal, A. K. "*Engineering Mechanics-Statics and Dynamics*." 2011.
2. Timoshenko S.P and Young D.H., "*Engineering Mechanics",* McGraw Hill International Edition, 1983.
3. Bhattacharyya, Basudeb. *Engineering Mechanics*. Oxford University Press India, 2016.
4. Shames, I.H., and Krishna MohanaRao. G., "Engineering Mechanics – Statics and Dynamics", 4th Edition, Pearson Education (2006)

Web Resources: https://nptel.ac.in/courses/112103109// https://nptel.ac.in/courses/112103108//

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

Solve resultant of forces acting on a body and analyze equilibrium of a body subjected to a system of forces

1. Solve problem on bodies subjected to friction.
2. Evaluate the location of Centroid and calculate moment of inertia of a given section.
3. Make a use of the concept of mass moment of inertia to real world applications.
4. Apply the kinetics and kinematics concepts to a body undergoing rectilinear, curvilinear, rotatory motion and rigid body motion.
5. Solve problems using work energy equations for translation, fixed axis rotation and plane motion and solve problems of vibration.

Assessment Method

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20CS1108	**Programming and Data Structures**	**ESC**	**3-0-0**	**3**

Course Objectives:

1. To understand the various steps in Program development.
2. To understand the basic concepts in C Programming Language.
3. To learn about arrays and character arrays
4. To learn how to write modular and readable C Programs
5. To understand the basic concepts of Pointers and Dynamic memory allocation.
6. To understand the usage of Structure and Unions and about file operations
7. To Understand the usage of Basic data structures

Course content

UNIT 1

Introduction, History Of Programming Languages, Character Set, Variables And Identifiers, Built-In Data Types. Variable Definition, Arithmetic Operators And Expressions, Constants And Literals, Simple Assignment Statement, Basic Input/output Statement, Simple 'C' Program , Conditional Statements And Loops.

UNIT 2

One Dimensional Arrays: Array Manipulation; Searching, Insertion, Deletion Of An Element From An Array; Finding The Largest/Smallest Element In An Array; Two Dimensional Arrays, Addition/Multiplication Of Two Matrices, Transpose Of A Square Matrix; Character Arrays

UNIT 3

Function Declaration, Function Definition, Function Call, Call By Value, Call By Reference, Recursion, String Handling Functions

UNIT 4

Structure Variables, Initialization, Structure Assignment, Nested Structure, Structures and Functions, Structures And Arrays: Arrays Of Structures, Structures Containing Arrays, Unions.

UNIT 5

Address Operators, Pointer Type Declaration, Pointer Assignment, Pointer Initialization, Pointer Arithmetic, Functions And Pointers, Arrays And Pointers, Pointer Arrays, Dynamic Memory Allocations, Storage Classes

UNIT 6

Linked List, Double Linked Lists, Stack, Stack Implementation Using Arrays, Stack Implementation Using Linked List.

Learning resources

Text book:

1. Reema Thareja, " Programming in C", Oxford Publications, 2nd Edition **Reference**

Books:

1. E. BalaguruSwamy, " Programming in ANSI C", Mc Graw Hill, 7th Edition
2. Brian W. Kernighan, Dennis M. Ritchie, " The C Programming Language", Prentice Hall, 2nd Edition
3. Data structures using C by Reema Thareja, 2nd edition ,Oxford Higher Education **Web resources :**

1. Indian Institute of Technology, Kharagpur, "Problem Solving through Programming in C", https://nptel.ac.in/courses/106105171/

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

1. Develop flowcharts, algorithms for given complex problems.
2. Analyze basic programming constructs.
3. Write C programs for real world problems. Implement C programming by using various control structures.
4. write rite modular and readable C Programs
5. use pointers in C programming.
6. Appreciate coding standards and best practices for program development.

Assessment Method

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20EG1181	English Language Communication Skills Lab-I	HSC	1-0-3	2.5

Course Objectives:

1. To facilitate computer-aided multi-media instruction enabling individualized and independent language learning
2. To sensitize the students to the nuances of English speech sounds, word accent, intonation and rhythm
3. To provide opportunities for practice in using English in day to day situations
4. To improve the fluency in spoken English and neutralize mother tongue influence
5. To train students to use language appropriately for debate, group discussion and public speaking

Course content

Unit-I **(06 Contact Hours)**

Theory: An Ideal Family by Katherine Mansfield

Spoken Skills: Situational Dialogues – Role-play – Expressions in various situations – Self Introduction – Introducing others – Greetings – Apologies – Requests – Giving directions

Unit-II **(06 Contact Hours)**

Theory: Energy -Alternative sources of Energy

Panel Debate on "On-grid & off-grid support to public participation in the production of solar energy in India", Reading the Wikipedia content on "The Green New Deal". Reflective session on the prospects of "The Green New Deal in India"

Writing Skills: Letter Writing (Formal & Informal) and Hands on Session on Letter Writing

Unit-III **(06 Contact Hours)**

Theory: Transport - Problems & solutions

Group Discussion on "The Future of Bullet Trains in India"

PPT on "The Dedicated Freight Corridors & the Future of Indian Economy" – Introduction to Speech

Spoken Skills: Sounds – Vowels, Consonants and Diphthongs – Pronunciation Exercises (Basic Level)

Unit-IV **(06 Contact Hours)**

Theory: Technology - Evaluating technology

PPT on "3R: Reduce, Recycle, Reuse" - Solo Debate on "Can Block Chain Technology Mitigate the Issue of Cyber Crimes and Hacking?"

Presentation Skills: JAM –Description of Pictures, Photographs, Process, Talking about wishes, Information Transfer

Unit-V **(06 Contact Hours)**

Theory: Environment - Ecology versus Development

Listening Skills: Listening Activity on YouTube video on "Greening the Deserts" - Students' seminar on "Waste to Wealth: Examples from around the Globe".

Unit-VI **(06 Contact Hours)**

Theory: Industry - Selling products

Reading Skills: Reading the material on "4Ps: Product, Price, Place, and Promotion" Role play on "How to sell your product and services"

References:

1. Non – Detailed Text Book: Panorama – A Course on Reading published by Oxford University Press, India
2. English for engineers and technologists by Orient Black Swan
3. A Textbook of English Phonetics for Indian Students 2nd Ed T. Balasubramanian. (Macmillan), 2012.
4. Speaking English Effectively, 2nd Edition Krishna Mohan & NP Singh, 2011. (Macmillan).
5. A Hand book for English Laboratories, E.Suresh Kumar, P.Sreehari, Foundation Books,2011
6. English Pronunciation in Use. Intermediate & Advanced, Hancock, M. 2009. CUP
7. Basics of Communication in English, Soundararaj, Francis. 2012.. *New Delhi: Macmillan*
8. English Pronouncing Dictionary, Daniel Jones Current Edition with CD.Cambridge, 17th edition, 2011.

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

CO 1	Understand the issues affecting the economy and environment in India and across the globe
CO 2	Develop the instinct for problem solution
CO 3	Develop the ability to collect materials on various socio-economic-technological issues and prepare PPT for presentation
CO 4	Improving listening skills
CO 5	Inculcate speaking as a behaviour by repeated practice and exposure

Assessment Method:

Course Nature: THEORY + LABORATORY

Internal Assessment (40 Marks)		**External Assessment (**60 Marks)	
Record Writing	– 10 Marks	Reading Comprehension	– 15 Marks
Attendance	– 10 Marks	Writing	– 30 Marks
Continuous Assessment (Listening – 10 Marks + Oral Presentations – 10 Marks)		Speaking (Viva-Voce)	– 15 Marks

Course code	Course name	Course Category	L-T-P	Credits
20PY1183	Physics Laboratory	BSC	0-0-3	1.5

Course Learning Objectives:

1. To study the Hall Effect and to calculate:-(i) The Hall Coefficient (RH) (ii) The concentration of charge carriers.
2. To determine the wavelength of laser light using Diffraction Grating.
3. To determine the Energy Band Gap of a Semiconductor by using a Junction Diode / Four Probe method
4. Magnetic Hysteresis Loop B-H loop
5. Measurement of velocity of ultrasonic waves
6. To verify the Bohr's postulates and quantization of energy levels
7. To determine the dispersive power of grating using mercury light with the help of a spectrometer.
8. To determine the dielectric constant of given material using capacitance method
9. To verify Stefan's law by electrical method
10. Study of I-V Characteristic of a solar cell illuminated by an incandescent lamp, at different frequencies
11. To determine the thermo electric coefficient of a given metals using Seebeck effect
12. Determination of thermal and electrical conductivity of metals
13. Determination of acceptance angle and numerical aperture using fiber optic cable

Experiments list

1. Hall Effect
2. Laser Diffraction
3. Four Probe Method - Energy Band Gap of a Semiconductor
4. Magnetic Hysteresis Loop
5. Ultrasonic interferometer
6. Frank Hertz
7. Spectrometer
8. Dielectric Constant
9. Stefan's Law
10. Solar Cells
11. Thermo electric coefficient of a given metals 12. Thermal and electrical conductivity of metals
13. Optical Fiber.

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

1. Student will able to calculate the Hall coefficient, carrier density and carrier mobility of a given semiconductor.
2. Student will able to understand the concept of diffraction of grating with this experiment.
3. Student will able to understand how to calculate the energy gap of a semiconductor.
4. Student will able to understand the magnetic properties of the material with B-H loop.
5. Student will able to understand how the velocity of ultrasonic waves varies in different media.
6. Student will able to verify the concept of quantization through this experiment.
7. Student will able to understand the dispersion of light through prism using spectrometer and measure their wavelengths
8. Student will able to understand how to calculate the dielectric constant of the given material.
9. Student will able to understand and verify the Stefan's law radiations.
10. Student will able to understand the I-V characteristic of Solar cells.
11. Student will able to understand thermo electric coefficient of a given metals.
12. Student will able to understand Thermal and Electrical conductivity of Metals.
13. Student will able to calculate the acceptance angle and numerical aperture using fiber optic cable.

Assessment Method				
Assessment Tool	Experiments	Record	Viva-Voce/ Quiz/MCQ/Lab project	Total
Weightage (%)	25%	5%	10%	40%
End Semester Examination weightage (%)				60%

Course code	Course name	Course Category	L-T-P	Credits
20CS1289	Programming for Data Structures Laboratory	ESCL	0-0-3	1.5

Course Objective:

1. Identify situations where computational methods and computers would be useful.
2. Given a computational problem, identify and abstractthe programming task involved.
3. Approach the programming tasks using techniques learned and write pseudo-code.
4. To understand the concepts of Programming language
5. To learn the basics of C declarations, operators and expressions 6. To learn on the manipulation of strings, functions and pointers
7. To apply concepts and techniques for implementation.
8. To learn the basic data structures and its usage

UNIT 1 **(Week1)**

1. C Program to calculate the sum of Natural numbers.
2. C Program to find factorial of a number
3. C Program to generate multiplication table of a given number.
4. C Program to display Fibonacci sequence (Up to given number)
5. C Program to Check whether a given number is prime or not
6. C Program to make a simple Calculator using switch case 7. C Program to check whether a number is palindrome or not
8. C Program to display factors of a given number.
9. C Program to print Pyramids and Triangles using loops.

UNIT II **(Week2&3)**

1. C Program to find second largest Element of an Array
2. C Program to add two matrix using multi-dimensional arrays.
3. C Program to multiply two matrix using multi-dimensional arrays.
4. C Program to find transpose of a matrix.
5. C Program to Sort Elements of an Array.

UNIT III **(Week4&5)**

1. C Program to check whether given number is prime or not using user-defined function.
2. C Program to check whether given number is Armstrong or not using user-defined function.
3. C Program to swap two integer values using call by value and call by reference.
4. C Program to find the sum of Natural numbers using recursion.
5. C Program to find the factorial of a given number using recursion.
6. C Program to calculate length of string without using strlen() function.
7. C Program to sort elements in Lexicographical order (Dictionary order) using in built string functions.

UNIT IV **(Week6&7)**

1. C Program using structures to read and display the information about a student.
2. C Program to read, display, add and subtract two complex numbers.
3. C Program to read and display the information of a student using nested structure.
4. C Program, using an array of pointers to a structure, to read and display the data of students.
5. C Program to demonstrate arrays of Union variables.

UNIT V **(Week8&9)**

1. C Program to demonstrate, handling of pointers in C.
2. C Program to access array elements using pointers.
3. C Program to find the sum of n numbers with arrays and pointers.
4. C Program to swap two numbers using pointers and function
5. C Program to find sum of n elements entered by user. To perform this allocate memory dynamically using malloc() function.
6. C Program to find sum of n elements entered by user. To perform this allocate memory dynamically using calloc() function.

UNIT VI **(week10&11)**

1. Write a program to create a linked list and perform insertions and deletions of all cases. Write functions to sort and finally delete the entire list at once.
2. Write a program to create a doubly linked list and perform insertions and deletions in all cases.
3. Write a program to perform push, pop and peek operations on a stack.
4. Write a program to implement a linked stack.

Course outcomes: At the end of the course, the student will be able

1. To formulate the algorithms for simple problems.
2. To translate the given algorithms to a working and correct program

3. To identify and correct logical errors encountered at run time
4. To write iterative as well as recursive programs
5. To represent Data in arrays, strings, Structures and manipulate them through a program
6. To decompose a problem into functions and synthesize a complete program 7. To be able to create basic data structures

Assessment Method

Assessment Method				
Assessment Tool	Experiments	Record	Viva-Voce/ Quiz/MCQ/Lab project	Total
Weightage (%)	25%	5%	10%	40%
End Semester Examination weightage (%)				60%

Course code	Course name	Course Category	L-T-P	Credits
20ME1186	Workshop Manufacturing Practices	ESCL	0-0-3	1.5

List of Experiments

2. **Safety:**

    a) Introduction to Workshop, Safety and Safety rules, Safety Slogans.
    b) Demonstration of tools and Equipment's used for safety purpose.

3. **Carpentry:**

    a. Study of tools, materials and equipment's used in Carpentry.
    b. Preparation of dovetail lap joint.
    c. Preparation of cross half lap joint.

4. **Fitting**

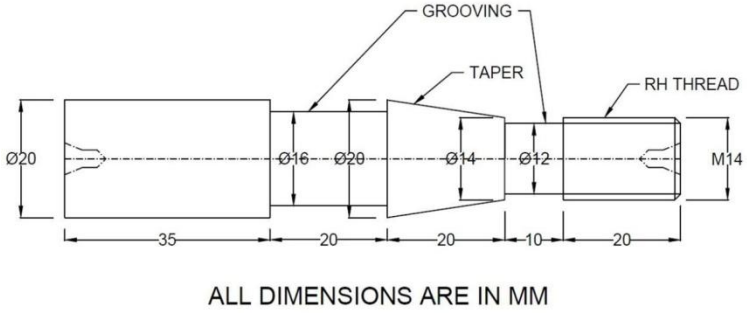
    a) Study of tools, materials and equipment's used in fitting.
    b) Preparation of Square fit from the given mid steel pieces
    c) Preparation of V fit from the given mid steel pieces

5. **Sheet Metal forming**

    a) Study of sheet metal forming tools.
    b) Fabrication of a Square Tray from G.I sheet

6. **Machining**

    a. Study the characteristic features of lathe, milling and drilling machines
    b. Preparation of the part shown in the sketch from a mild steel rod on a Lathe.



7. Smithy

a) Study of tools, operations and equipment's used in blacksmithy
b) Conversion of Round Rod to Square Rod through hot forging.

8. Welding

a) Preparation of arc welding of butt joints, lap joints and tee joints
b) Gas welding practice

9. Foundry

a) Study of foundry tools
b) Prepare Green Sand Mould for Bend Pattern

Assessment Method				
Assessment Tool	Experiments	Record	Viva-Voce/ Quiz/MCQ/Lab project	Total
Weightage (%)	25%	5%	10%	40%
End Semester Examination weightage (%)				60%

Course code	Course Name	Course Category	L-T-P	Credits
20MA1201	Mathematical Methods	BSC	3-1-0	4

Course Learning Objectives: The objective of this course is to

1. Introduce vector spaces and linear transformation.
2. Discuss Eigen values and Eigen vectors of a matrix and various properties.
3. Setup double and triple integrals to find volume and surface area.
4. Discuss directional derivatives and application of Green's, Stokes and Gauss theorems.
5. Discuss numerical methods to find the roots of transcendental equations and Interpolation.
6. Evaluate integrals by using numerical methods and solving IVP.

Course Content:

Unit – I: Linear Algebra: (12 hours)

Vector Spaces, Linear Combinations of Vectors, Linear dependence and Independence, Basis and Dimension, Linear Transformations, Matrix Representations of Linear transformation.

Unit – II: Eigen values and Eigen vectors: (8 hours)

Solving system of Homogeneous and Non-Homogeneous equations by using Gauss elimination method. Characteristic roots and Characteristic Vectors of a matrix - CayleyHamilton Theorem (without proof); Finding inverse and power of a matrix by Cayley-Hamilton Theorem;, properties of symmetric, Orthogonal, Idempotent matrix Complex matrices, Hermitian and Unitary Matrices.

Unit-III: Multiple integrals: (10 hours)

Double and triple integrals, computations of surface and volumes, Jacobeans of transformations, change of variables in double integrals, Change of Order of double integrals, integrals dependant on parameters - applications.

Unit–IV: Vector calculus: (12 hours)

Scalar and vector fields, level surfaces, directional derivative, Gradient, Curl, Divergence, Laplacian, line and surface integrals, Green, Gauss and Stokes theorems and problems.

Unit – V: Root finding Methods and Interpolation: (10 hours)

Roots of polynomial and transcendental equations – bisection method, Regula-falsi method and Newton-Raphson method, Finite differences, Newton's forward and backward interpolation formulae.

Unit – VI: Numerical integration and numerical solution of IVP: (8 hours)

Trapezoidal rule, Simpson's $1/3^{rd}$ rule and $3/8^{th}$ rule for numerical integration, Solution of IVP by Euler and Runga-Kutta method.

Learning resources

Text book:

1. ERWIN KREYSZIG**, '***Advanced Engineering Mathematics'*, Wiley-India, 9th Edition.

Reference Books:

1. R. K. Jain and S. R. K. Iyengar**,** '*Advanced Engineering Mathematics',* Narosa Publishing House, New Delhi, 3rd Edition.
2. B.S.Grewal, '*A Text Book of Higher Engineering Mathematics'*, Khanna Publishers, 43rd Edition.
3. Gilbert Strang , 'Linear Algebra and its Applications*'*, CENGAGE Learning 4th Edition.

Web resources:

1. https://onlinecourses.nptel.ac.in/noc20_ma54/preview
2. https://onlinecourses.nptel.ac.in/noc21_ma11/preview
3. RGUKT content

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

CO 1	Write Matrix representation for transformations.
CO 2	Find Eigen values and Eigen vector for a Matrix.
CO 3	Setup and evaluating double and triple integrals.
CO 4	Apply Green's Stokes and Gauss Divergence Theorems.
CO 5	Approximate the roots of polynomial and transcendental equations.
CO 6	Approximate the Integral value by numerical methods and solve IVP using numerical methods.

For Theory courses only:

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20CY1204	Engineering Chemistry	BSC	3-0-0	3

Course Learning Objectives:

1. To get knowledge on types of water and problems and solution associated with water.
2. To gain the knowledge on fuels, its analysis and determining physical property of lubricants.
3. To understand factors involved in the organic reaction to get products
4. To know types of compounds and its characterization techniques
5. To gain knowledge on adsorption and its application **6.** To know the characterization of nanomaterials

Syllabus

UNIT- I : Water Technology (7 Hours)

Hard water:- Reasons for hardness – units of hardness - Boiler troubles – Priming and Foaming, Scale formation, Boiler corrosion, Caustic embrittlement - Internal treatments - Softening of Hard water : Lime – Soda process, Zeolite process and numerical problems based on these processes and Ion Exchange process - Water for drinking purposes- Purification – Sterilization and disinfection : Chlorination, Break point chlorination and other methods – Reverse Osmosis and Electro Dialysis.

UNIT- II: Fuels & Lubricants (7 Hours)

Fuels - Classification, examples, relative merits, types of coal, determination of calorific value of solid fuels, Bomb calorimeter, theoretical oxygen requirement for combustion, proximate & ultimate analysis of coal, manufacture of metallurgical coke, flue gas analysis, problems. Lubricants - Definition, theories of lubrication, characteristics of lubricants, viscosity, viscosity index, oiliness, pour point, cloud point, flash point, fire point, additives to lubricants, Solid lubricants.

UNIT- III Organometallic Chemistry (7 Hours)

Introduction to organometallic chemistry, Structure and bonding - fluxional molecules, Ligands, Preparation and reactivity of RMgX, Ferrocene, Gilman reagent. Applications of organometallic complexes in organic synthesis (RMgX) and industrial catalysis (Organopalladium reagents), medical applications of Cis-Platin, Ligand to Metal and Metal to ligand Charge Transfer process and its analytical applications.

UNIT-IV: Analytical Techniques (9 Hours)

Absorption Spectroscopy: Beer-Lambert's law and its limitations, transmittance, Absorbance, and molar absorptivity; Application of Beers-Lamberts law for simultaneous quantitative analysis of Cr in $K_2Cr_2O_7$, Mn in $KMnO_4$

Infrared Spectroscopy – Introduction, Principle, Modes of vibrations, Signal characteristicsWave number.

Powder X-Ray Diffraction – Braggs' law and Scherrer's Equation, Electron Microscopy – Electron Specimen Interactions – Principle and applications of SEM, TEM

UNIT V Surface Chemistry and Catalysis (7 Hours)

Adsorption-Types of adsorption-adsorption of gases on solids- adsorption from solutions- Types of isotherms Frendlich adsorption isotherm, Langmuir adsorption isotherm. Industrial applications of adsorption. Catalysis: Characteristics and types of catalysts-homogeneous and heterogeneous, auto catalysis, Industrial applications of catalysts.

Unit VI: Introduction to Nanomaterials and Nanotechnology (8 Hours)

Nanomaterial: Introduction to Nanostructures: Carbon Nanotubes (CNT), Graphenes, Fullerenes, Quantum Dots and Semiconductor Nanoparticles Metal-based Nanostructures (Iron Oxide Nanoparticles) Nanowires, Introduction to metal based nanostructures, Nanobiosensors: Science of Self-assembly - From Natural to Artificial Structures Nanoparticles in Biological Labeling and Cellular Imaging.

Learning Resources:

Text Books:

1) P. C. Jain, Monica Jain, "*Engineering Chemistry*", Dhanpat Rai Publishing Company, 15th Edition, 2015
2) Shasi Chawla, "*Text Book of Engineering Chemistry*", Dhantpat Rai Publishing Company, New Delhi, 1st Edition, 2011.
3) Jain & Jain, *Engineering Chemistry*, 16th Edition, 2015
4) *Advanced Chemistry – Volumes 1 and 2 by Philip Matthews, Paperback, Cambridge University Press* **References:**

1. *Theories and Practices of Industrial waste treatment*- Nelson Nemerow.
2. *Engineering Chemistry* by Shikha Agarwal; Cambridge University Press, 2015 edition.
3. Pahari A., Chauhan B., "*Engineering Chemistry*", Firewall Media, New Delhi, 2012.
4. AshimaSrivastava. Janhavi N N, "*Concepts of Engineering Chemistry*", ACME Learning Private Limited., New Delhi., 2010.
5. Vairam S., Kalyani P., Suba Ramesh., "*Engineering Chemistry*", Wiley India Pvt Ltd., New Delhi., 2011
6. *Physical Chemistry*, Peter Atkins, Julia de Paula, 9th Edition, Oxford University Press, 2011.

7. Organotransition Metal Chemistry – From Bonding to Catalysis, John F. Hartwig, ISBN-13: 978-1891389535

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

CO 1	Develop different methods for attaining soft water by different treatment procedures.
CO 2	Analyze fuel property and determine efficiency of different fuels.
CO 3	Derive the factors involved in reaction to get products
CO 4	Distinguish different types of polymers and analyze their property.
CO 5	Derive adsorption isotherms and characterize catalyzing activity
CO 6	Characterize of chemical compound by using UV-Vis, IR, XRD, and EM

Course Nature		Theory		
Assessment Method				
Assessment Tool	Weekly tests (In semester)	Monthly tests (In semester)	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20EE1209	Basic Electrical and Electronics Engineering	ESC	3-0-0	3

Course Objectives:

1. Impart a basic knowledge of electrical quantities such as current, voltage, power, energy and frequency to understand the impact of technology.
2. Provide knowledge for the analysis of basic DC and AC circuits used in electrical and electronic devices.
3. Explain the working principle, construction, applications of DC and AC machines.
4. Realize the importance of electronic devices in the present technology.

Course Content:

Unit-1 **(8Hrs)**

Introduction, Basic definitions, Types of elements, Ohm's Law, Kirchhoff's Laws, Series, Parallel circuits, Star-delta and delta-star transformations, equivalent resistance calculation, Mesh and Nodal analysis, superposition theorem, thevenin's theorem and maximum power transfer theorem.

Unit-2 **(7 Hrs)**

Single-phase: Inductive circuits, capacitive circuits, series RL, RC and RLC circuits, resonance; Three-phase: star connection and delta connection

Unit-3 **(8 Hrs)**

Generator: Principle of operation of DC Generator, EMF equation, types, applications; Motor: DC motor types, torque equation, applications, three point starter.

Unit-4 **(7 Hrs)**

Transformers: Principle of operation of single phase transformers, EMF equation, losses, efficiency and regulation; Induction machine: Principle of operation of induction motor, sliptorque characteristics, applications.

Unit-5 **(8 Hrs)**

Diode: types of semiconductors, P-N junction diode, V-I Characteristics, zener diode, Diode Applications; Rectifiers: Half wave, Full wave and Bridge rectifiers.

Unit-6 **(7 Hrs)**

PNP and NPN Junction transistor, Transistor configurations, Transistor as an amplifier.

Learning resources

Text book:

1. D.P. Kothari, I.J. Nagrath, "Basic Electrical and Electronics Engineering", McGraw Hill Education; 1st Edition, 2017.
2. Mehta V K and Rohit Mehta, "Principles of Electrical Engineering and Electronics", S.Chand and Co. New Delhi, 2010 **Reference Books:**

1. Pillai S K, "A first course on Electrical Drives", New Age International, 2011.
2. Murugesh Kumar K, "Basic Electrical Science & Technology", Vikas Pub., 2011.
3. Roy Choudhury and Shail Jain, "Linear Integrated Circuits", New Age International Limited, 2003.
4. Leach D P, Malvino A P and Goutam Saha, "Digital Principles and Applications", Tata McGraw Hill, 2008 **Web resources:**

1. IIT Madras, 'Basic Electronics', URL: https://nptel.ac.in/courses/122106025/
2. IISC Bangalore, 'Basic Electrical Technology', URL: http://nptel.ac.in/courses/108108076/
3. IIT Madras, 'Basic Electrical Circuits', URL: https://onlinecourses.nptel.ac.in/noc16_ee03 **Course outcomes:**

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

1. Predict the behaviour of any electrical and magnetic circuits.
2. Formulate and solve complex AC, DC circuits
3. Identify the type of electrical machine used for that particular application
4. Realize the requirement of transformers in transmission and distribution of electric power and other applications
5. Utilize the semiconductor devices like diodes and transistors
6. Internlink Knowledge of electrical and electronic circuits to general problems

Assessment Method

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MM1201	Materials Thermodynamics	PCC	3-1-0	4

Course Objectives:

1. To lean fundamental concepts and first law of thermodynamics
2. To introduce concept of entropy, free energy and Maxwell's relations
3. To understand thermodynamics potentials and third law of thermodynamics.
4. To study about thermodynamics solutions
5. To learn phase diagrams and its application in metallurgical field.
6. To introduce knowledge on electrochemical processes and kinetics.

Course Content:

Unit-I **(10 Hrs)**

Concepts of system and state, heterogeneous and homogeneous systems, extensive and intensive properties of system, thermodynamic variables, thermodynamic equilibrium, Reversible and irreversible processes. First Law of thermodynamics: Heat and work, internal nergy, heat capacity of materials, enthalpy, thermo chemistry Hess's law, Kirchoff's law.

Unit-II **(10 Hrs)**

Second Law of Thermodynamics: Carnot cycle, entropy-statistical interpretation of entropy, combined statement of first and second laws, Free energy, thermodynamic functions-Maxwell's relations, Gibbs-Helmholtz equation, effect of temperature on the thermodynamic properties.

Unit-III **(10 Hrs)**

Thermodynamic Potentials: fugacity, activity and equilibrium constant. Clausius - Clayperon equation. Le Chatelier's principle, Vant Hoff's equation. Third laws of thermodynamics, applications.

Unit-IV **(10 Hrs)**

Gibbs - Duhem equation, partial and integral molar quantities, ideal solutions- Raoult's law, real solutions, activity coefficient, Henry's law, alternative standard states, Sievert's law, mixing functions and excess functions, regular solutions, applications of Gibbs-Duhem equation.

Unit-V **(7 Hrs)**

Phase rule, phase stability, P-G-T diagrams, Ellingham diagram and its use-application of free energy- composition diagrams to the study of alloy systems. Free energy-temperature diagram for metastable phases.

Unit-VI **(13 Hrs)**

Electro Chemical Process: Cells, interconvertion of free energy and electrical work, determination of thermodynamic quantities using reversible cells, solid electrolytic cells. Kinetics: First, second and third order reactions, Arrhenius equation-activation energy, determination of order of the reaction.

Learning resources

Text book:

1. David R Gaskell,"Introduction to the Thermodynamics of materials", Taylor and Francis, Fifth edition, 2008.
2. Upadhyaya G S and Dube R K, "Problems in Metallurgical Thermodynamics and Kinetics", Pergamon, 1977. **Reference Books:**

1. Ahindra Ghosh, "Textbook of Materials and Metallurgical Thermodynamics", Prentice hall of India, 2003.
2. Prasad, Krishna Kant, Ray, H. S. and Abraham, K. P., "Chemical and Metallurgical Thermodynamics", New Age International, 2006.
3. R. H. Tupkary, "Essentials of Metallurgical Thermodynamics", Khanna Publishers, First edition, 2016
4. Dutta S.K., Lele A.B." Metallurgical Thermodynamics Kinetics and Numericals", S Chand Publishers, First edition, 2017

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

1. Explain thermodynamic basic concepts and calculate heat of metallurgical reaction
2. Discuss disorder/randomness of the system
3. Identify feasibility of thermodynamics reaction through thermodynamics potentials
4. Perform calculation of free energy change, partial molar quantities, solubility of gas during preparation of solutions
5. Read phase diagrams & Ellingham diagram
6. Explain electrochemistry and kinetics of metallurgical reactions

Assessment Method

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MM1202	Physical Metallurgy	PCC	3-1-0	4

Course Objectives:

1. To provide a brief knowledge on crystallography of solids
2. To learn crystal imperfections and properties of materials
3. To learn about the principles of alloy design
4. To study construction and interpretation of phase diagram.
5. To understand phenomena of diffusion in solids.
6. To obtain knowledge about the physical metallurgy of important engineering materials.

Course Content:

Unit-I **(10 Hrs)**

Review of atomic bonds; Atomic Arrangement in Materials: Concept of crystalline and amorphous solids, Space lattice and Unit cell, Crystal system and Bravais Lattices, Common crystal structure of metals, Crystallographic planes and directions, Voids in crystal structures; Allotropy.

Unit-II **(10 Hrs)**

Plastic deformation of pure metal: Mechanisms (slip& twin), critical resolved shear stress, single crystal tensile test (fcc), theoretical strength of ideal crystal. Crystal defects: Point defects, Line defects, Planer defects, Volume defects, Physical Properties of Materials: Thermal Properties, Electrical Properties, Magnetic Properties, Optical Properties.

Unit-III **(10 Hrs)**

Solid solution, definition and types of solid solution, Substitutional and Hume Rothery Rules, Intermetallic compounds, Normal valency compounds, Electron compounds, Interstitial compounds. Interaction of dislocation and solute atom. Definitions and basic concept phase diagram, Single component or Unary phase diagram, Binary Phase Diagrams: Isomorphous, Eutectic, Peritectic, Eutectoid, Monotectic & Syntectic reactions, Phase rule and Lever rule. Free energy and phase diagrams of ideal binary solutions. Common tangents to free energy curves.

Unit-IV **(10 Hrs)**

Detailed study of Fe-Fe_3C, Cu- Ni, Zn-Sn, Fe-C, Cu-Sn, Cu-Zn, Pb-Sn, Al-Si, Al-Cu phase diagrams. Nucleation, Homogeneous and Heterogeneous nucleation, Kinetics of nucleation, Growth and overall transformation kinetics, TTT and CCT diagrams.

Unit-V **(12 Hrs)**

Strengthening Mechanisms: Grain size strengthening-solid solution strengthening-factors affecting solid solution strengthening. martensitic strengthening, precipitation

hardeningconditions for precipitation hardening-aging-formation of precipitates-coarsening of precipitates, mechanism of strengthening. dispersion strengthening-Introduction, factors for effective dispersion hardening-strengthening mechanism-examples for above strengthening mechanisms-worked examples.

Unit-VI **(8 Hrs)**

Engineering Alloys: Ferrous alloys (stainless and special steels, cast irons), Non-ferrous alloys (Aluminum alloys, titanium alloys, copper base alloys). Metallography - Micro and Macro examinations, Principle and working of simple metallurgical microscope.

Learning resources

Text book:

1. Raghavan V, "Physical Metallurgy - Principles and Practice", PHI Learning Private Limited-New Delhi; 3rd edition, 2015.
2. William D. Callister, Jr., "Materials Science and Engineering an Introduction", John Wiley & Sons, Inc., 2nd Edition, 2007.
3. Donald R. Askeland, Pradeep P. Phule, "The Science and Engineering of Materials", Thomson Learning, 5th Edition, 2007.

Reference Books:

1. Reza Abbaschian, Robert E. Reed-Hill, "Physical Metallurgy Principles", Cengage, 4th edition, 2013.
2. Sidney H. Avner, "Introduction to Physical Metallurgy", McGraw Hill Education; 2nd edition, 2017
3. Vijendra Singh, "Physical Metallurgy", Standard Publishers Distributors, New Delhi, 2012.

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

1. Recognize the wide range of characteristics of metals due to crystal structure variation
2. Explain the properties of materials based on crystal defects
3. Design alloys system and predict microstructure formation 4. Perform phase equilibrium calculation and construct phase diagram.
5. Discuss the phenomenon of diffusion in solid.
6. Select suitable materials for engineering application.

Assessment Method

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20CY1284	Engineering Chemistry Laboratory	BSC	0-0-3	1.5

Course Learning Objectives:

1. To understand the water quality in terms of hardness
2. To know the metal percentage present in alloys.
3. To prepare chemical substances like soap, sulphur based polymer
4. To study the physical property of chemical compounds
5. To derive adsorption isotherm
6. To identify properties of different fuels.

Practical Syllabus

List of Experiments:

1. Determination of temporary and permanent hardness of water using standard EDTA solution.
2. Determination of percentage of copper in brass
3. pH-metric titrations
   a. strong acid and strong base.
   b. strong acid and weak base.
4. Conductometric titrations
   a. strong acid and strong base.
   b. strong acid and weak base.
5. Potentiometric titrations
   a. strong acid and strong base.
   b. $K_2Cr_2O_7$ and Mohr's salt.
6. determination of copper by Electro-gravimetric analysis.
7. Determination of Iron by a Jobs method
8. Determination of density and surface tension of liquids against air
9. Determination of viscosities of pure liquids and solutions 10. Adsorption of oxalic acid by Charcoal
11. Fuel Characterization:
    a. Flash point, Fire point
    b. Ash content

Learning Resources: Text Books:

1. *Chemistry Practical Manual*, Lorven Publications
2. K. Mukkanti (2009) *Practical Engineering Chemistry,* B.S. Publication
3. Arthur J. Vogel, *A Textbook of Quantitative Analysis*.
4. Dr. Jyotsna Cherukuris *Laboratory Manual of engineering chemistry-II,* VGS Techno Series, 2012.

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

CO 1	Ability to judge water quality of different places in terms of hardness.
CO 2	Estimate metal percentage in brass
CO 3	Handle chemical compounds during synthesis of chemical compounds.
CO 4	Derive the physical characterization like size, surface tension and viscosity of chemical substances
CO 5	Derive adsorption isotherms and characterize catalyzing activity
CO 6	Analyze the physical properties of different fuels

Course Nature		Practical		
Assessment Method				
Assessment Tool (In semester)	Experiments related	Record	Viva-Voce/ Quiz/MCQ/Lab project	Total
Weightage (%)	20%	10%	10%	40%
Assessment Tool (End semester)	Procedure/Description of the experiment with relevant information and Discussion on Results	Results	Viva-Voce	
Weightage (%)	30%	10%	20%	60%

Course Code	Course Name	Course Category	L-T-P	Credits
20EE1289	Basic Electrical and Electronics Engineering Laboratory	ESC	0-0-3	1.5

List of Experiments

1. Verification of ohm's law, series and parallel circuits
2. Verification of Kirchhoff's Laws
3. Verification of theorems (Thevenin's and maximum power transfer)
4. V-I characteristics of Incandescent and CFL lamp
5. V-I characteristics of Fluorescent lamp
6. A.C analysis of series R-L circuit and R-C circuit
7. Calibration of Energy meter
8. Open circuit characteristics of D.C Generator
9. Speed control of D.C shunt Motor
10. Three phase power measurement
11. V-I characteristics of a P-N junction diode and zener diode
12. Half wave and center tapped full wave rectifier
13. Full wave bridge Rectifier with and without filters.
14. Characteristics of Common emitter configuration of a transistor
15. Measurement of I-V characteristic of Solar cells
16. Study and verify the thermo electric coefficient of a given metals
17. Determination of thermal and electrical conductivity of metals
18. Determination of acceptance angle and numerical aperture using fiber optic cable

Assessment Method

Assessment Tool	Experiments	Record	Viva-Voce/ Quiz/MCQ/Lab project	Total
Weightage (%)	25%	5%	10%	40%
End Semester Examination weightage (%)				60%

Course Code	Course Name	Course Category	L-T-P	Credits
20MM1281	**Physical Metallurgy and Metallography Laboratory**	**PCC**	**0-0-3**	**1.5**

List of Experiments

1. Preparation and study of Crystal models.
2. Study of Metallurgical Microscope.
3. Study of specimen cutting machine, specimen mounting method, grinding and polishing technique for Metallographic Examination.
4. Metallographic preparation and microstructure evaluation of
   a) Low carbon steel b) Medium carbon steel c) High carbon steel
5. Metallographic preparation and microstructure evaluation of
   a. Austenitic Stainless steels, b. High Speed Steels.
6. Metallographic preparation and microstructure evaluation of
   a. White Cast Iron, b. Malleable Cast Iron, c. Nodular Cast Iron, d. Grey Cast Iron
7. Study of Fe-Fe_3C Phase Diagram
8. Metallographic preparation and microstructure evaluation of
   a. Copper, b. Red brass, c. Yellow brass
9. Metallographic preparation and microstructure evaluation of
   a) Aluminum b) Aluminum alloy
10. Study of quantitative metallography and estimation of Grain size and Volume fraction.
11. Study of Macro etching and Sulphur printing

Assessment Method

Assessment Tool	Experiments	Record	Viva-Voce/ Quiz/MCQ/Lab project	Total
Weightage (%)	25%	5%	10%	40%
End Semester Examination weightage (%)				60%

Course Code	Course Name	Course Category	L-T-P	Credits
20HS1201	Indian Constitution	MC	2-0-0	0

Course Learning Objectives:

1. The basic objective of the course is to provide knowledge about institutions 2. It help to understands the processes to governing the society in a systematic way.
3. It helps to establish social Justice, Liberty, Equity and Fraternity.
4. The course will introduce the idea of political system in general
5. It provides idea about working process of constitutional institutions.
6. To create awareness about the functioning of the judicial system in India. **Course Contents:**

UNIT I: **(5 hours)**

Introduction-Constitution' meaning of the term, Indian constitution sources and constitutional history, Features: Citizenship, Preamble, Fundamental Rights and duties, Directive Principles of State Policy.

UNIT II: **(5 hours)**

Union Government and its Administration-Structure of the Indian Union: Federalism, centrestate relationship, President: Role, power and position, PM and Council of ministers, Cabinet and Central Secretariat, Lok sabha, Rajya sabha.

UNIT III: **(5 hours)**

Election commission- Election commission: Role and functioning, Chief Election Commissioner and Election Commissioners, State Election Commission: Role and functioning, Institute and Bodies for the welfare of SC/ST/OBC and women.

UNIT IV: **(3 hours)**

State Government and its Administration- Governor: Role and position, CM and Council of ministers, state secretariat: Organization, structure and functions.

UNIT V: **(7 hours)**

Local Administration-District's Administration head: Role and importance, Municipalities: Introduction, Mayor and role of Elected Representatives, CEO of Municipal Corporation, Panchayati raj: Introduction, PRI: Zilla Panchayat, Elected officials and their roles, CEO Zilla Panchayat: Position and role, Block level: Organizational Hierarchy (different departments), Village level: Role of elected and appointed officials, Importance of grass root democracy.

UNIT VI: **(5 hours)**

Union Judiciary-Establishment and constitution of Supreme court, Appointment of Judges, Establishment of State High court, Establishment of common High court for 2 or more states, WRITS, PIL(Public Interest Litigation).

Learning resources Text book:

1. Durga Das Basu, *Constitutions of India*, 23rd ed, LexisNexis Publication.

Reference Books:

1. 'Indian Polity' by Laxmikanth
2.'Indian Administration' by Subhash Kashyap
4.'Indian Administration' by Avasti and Avasti
5.'Government and Politics of India' by W.H.Mrrison Jones
6.'Constitution of India' by J.C.Johari

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

CO 1	The students will understand their fundamental rules and duties.
CO 2	The students will learn the political system and the system of elections in India.
CO 3	It is to provide the students the institutions and processes to govern themselves in the manner they prefer.
CO 4	Students can also be able to utilize the laws and facilities provided by constution
CO 5	It will provide over all idea about our legal system.
CO 6	It will enable students more strong in terms of law and practice in day to day life.

Course code	Course Name	Course Category	L-T-P	Credits
20MA2103	Transform Calculus	BSC	3-0-0	3

Course Learning Objectives: The objective of this course is to 1. Introduce partial differential equations and solutions of first order PDE.
2. Introduces the concept of transforms and their mathematical properties.
3. Apply Laplace transforms to solve the ordinary and partial differential equations which are not solvable by traditional analytical methods.
4. Write Fourier series expansion of periodic and non-periodic functions.
5. Introduce Fourier transforms and their properties.
6. Apply transformation techniques to solve boundary value problems.

Course Content:

UNIT-I

Laplace Transform: (10 hours)

Definition of Laplace Transform, linearity property, conditions for existence of Laplace Transform. First and second shifting properties, Laplace Transform of derivatives and integrals, unit step functions, Dirac delta-function, error function.

UNIT-II

Application of Laplace transforms: (07 hours)

Differentiation and integration of transforms, convolution theorem, inversion, periodic functions. Evaluation of integrals by Laplace Transform. Solution of Ordinary differential Equations.

UNIT-III

Fourier Series: (08 hours)

Periodic functions, Fourier series representation of a function, Fourier series for Even and Odd functions, half range sine and cosine series, Fourier integral Theorem, Parseval's identity.

UNIT-IV

Fourier Transform: (05 hours)

Fourier Transform, Fourier sine and cosine transforms. Linearity, Scaling, frequency shifting and time shifting properties.

Unit-V: (07 hours)

Inverse Fourier Transforms, Self reciprocity of Fourier Transform, convolution theorem.

UNIT-VI

Boundary Value Problems: (08 hours)

Relation between Fourier and Laplace Transforms, Solutions of boundary value problems by Fourier Transforms.

Learning resources

Text book:

1. ERWIN KREYSZIG, '*Advanced Engineering Mathematics',* Wiley-India, 9th Edition.

Reference Books:

1. M.K. Jain., '*Numerical solutions of differential equations',* Wiley Eastern, 1984, 2nd Edition.
2. M.K Jain, S.R.K Iyengar, R.K Jain., '*computational methods for PDE*,' Wiley Eastern 1994.
3. S.D. Conte &Carl de Boor., '*Elementary Numerical analysis an algorithmic approach'*, McGraw Hill, Newyork, 1980, 3rdEdition.
4. E. Ward Cheney**,** David R. Kindcaid.,' *Numerical methods and applications'*, Brooks / Cole, 2008.
5. Butcher, J.C, '*Numerical methods for ordinary differential equations'*, Wi- ley, Newyork, 2003.

Web resources:

1. https://onlinecourses.nptel.ac.in/noc19_ma04/preview.
2. RGUKT content.

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

CO 1	Solve the partial differential equations of first and second order.
CO 2	Solve the ordinary differential equations with discontinuous forcing terms.
CO 3	Able to analyze the solutions with various initial and boundary conditions.
CO 4	Able to write series expansions of periodic functions and their physical significance.
CO 5	Solve the various forms of ODEs and PDEs.
CO 6	Solve the various types of differential equations such as Integro- differential equations, System of differential equations.

For Theory courses only:

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MM2101	Mineral Processing and Extractive Metallurgy	PCC	3-1-0	4

Course Learning Objectives:

1. To introduce mineralogy and ore sampling. Further to familiarize on principles of grinding operations and grinding mills.
2. To understand the physical laws of moving solid in fluids.
3. To study principals and equipment's of heavy media separation, jigging and tabling operations.
4. To study principals and equipment's of floatation, magnetic separation processes; electrostatic separation processes.
5. To provide thermodynamics and kinetics concepts involved in metals extraction.
6. To explain various techniques, unit process and operations used in metal extraction.

Course Content:

UNIT I **(12 Hrs)**

Mineralogy: Physical Properties of Minerals, Classification of various Rock Forming Minerals and its Occurrence, Ore sampling; Comminution: Theory of liberation of minerals, Crushers - Jaw, Gyratory, Cone, Rolls and toothed roll crushers, Types of grinding operations, Grinding Mills - Critical Velocity, Ball mills, Rod mills, tube mills and Stirred mills, Comminution laws - Rittinger's laws, Kick's law and Bond's law; Screening, sizing and sampling.

UNIT II **(8 Hrs)**

Stokes and Newton's laws, Terminal velocity and its relation with size, Relation between time and velocity, Relation between distance traveled and velocity, Equal settling ratio, Free and hindered settling ratios, Quantifying concentrating operations: Ratio of concentration, recovery, selectivity index and economic recovery. Classification of classifiers, study of settling cones, rake classifier, spiral classifier and cyclones.

UNIT III **(10 Hrs)**

Heavy media separation: Principles, flow chart, different media used, Heavy media separation using heavy liquids and heavy suspensions, Washability curves for easy, normal and difficult coal; Jigging: Theory of jigging, Jigging machines, Design considerations in a jig; Tabling: Study of stratification on a table, Shaking tables, Wilfley table, Humphrey's spiral classifier.

UNIT IV **(10 Hrs)**

Flotation: Principles of flotation, Factors affecting flotation, Classification of collectors and frothers, Regulators factors affecting their efficiency, Flotation machines-Pneumatic and mechanical flotation cells, Application of flotation process for Cu, Pb and Zn ores; Magnetic separation processes; Electrostatic separation process; Dewatering techniques.

UNIT V **(10 Hrs)**

Thermodynamic basis of metal extraction: Ellingham diagrams, predominance area diagrams, Pourbaix diagrams, concept of activity and activity scales; Slags and mattes and their

physicochemical properties; Kinetics of extraction process: kinetic theory, reaction rate theory, reaction across interfaces.

UNIT VI **(10 Hrs)**

Pyrometallurgy: Principles of roasting and smelting; Hydrometallurgy: Principles of leaching, types of leaching, Properties of leaching solutions; Electrometallurgy: Principles of electrowinning and electrorefining; Types of electrolytes: Aqueous and non-aqueous electrolytes; Refining: Principles of refining, Different methods of refining.

Learning resources

Text book:

1. Barry A. Wills, James Finch, "Mineral Processing Technology: An Introduction to the Practical Aspects of Ore Treatment and Mineral Recovery" Butterworth-Heinemann; 8 edition, 2015
2. Ghosh and H.S. Ray, "Principles of extractive metallurgy" New Age International Publishers; Third edition, 2018 **Reference Books:**

1. S. K. Jain, "Mineral Processing", CBS, 2 edition, 2001.
2. Maurice C. Fuerstenau, Kenneth N. Han, "Principles of Mineral Processing" Society for Mining, Metallurgy, and Exploration, 2003.
3. Terkel Rosenqvist, "Principles of Extractive Metallurgy", McGraw Hill, London, 1983.
4. Sujay Kumar Dutta, Avinash B. Lele, Yakshil B. Chokshi, "Extractive Metallurgy: Processes and Applications" PHI Learning Private Limited, First edition, 2017.
5. Alain Vignes, "Extractive Metallurgy 1: Basic Thermodynamics and Kinetics", WileyISTE, 1 edition, 2011
6. Chiranjib Kumar Gupta "Chemical Metallurgy: Principles and Practice" Wiley VCH, 2003.

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

1. Identify the characteristics of different ores and minerals
2. Build the solid foundation on principals and equipment of various mineral beneficiations procedures that would facilitate metal extraction.
3. Use the techniques, skills, and modern engineering tools necessary for different ore dressing processes
4. Apply principles of thermodynamics and kinetics to reactions involving extraction of metals
5. Analyze different extraction processes

Assessment Method

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MM2102	Phase Transformations and Heat Treatment	PCC	3-1-0	4

Course Learning Objectives:

1. To learn thermodynamics and kinetics principles involved in the phase transformation of materials
2. To understand diffusion and diffusionless phase transformation involved in materials.
3. To study fundamental principles involved in heat treatment of ferrous and non ferrous alloys.

Course Content:

UNIT I **(10 Hrs)**

Free energy of elemental crystal and solid solutions, classification of phase transformations, kinetics of nucleation and growth homogeneous and heterogeneous nucleation, strain energy effect, interface control and diffusion control growth. Overall transformation kinetics Empirical equations, The Johnson-Mehl model and Avrami model.

UNIT-II **(10 Hrs)**

Classification, KJMA kinetics, Precipitation reactions, Spinodal decomposition, Particle coarsening, Cellular precipitation, Eutectoidal transformation, Order-disorder transformation

UNIT-III **(10 Hrs)**

Martensitic transformations: characteristics, crystallography, theories of Martensitic nucleation, martensite growth, Tempering of Ferrous Martensites, martensite in non-ferrous systems, Shape memory effect

UNIT-IV **(10 Hrs)**

Definition and objectives of heat treatment; Heat treatment of steel: Iron-carbon equilibrium diagram, transformations on heating and cooling Isothermal transformation diagrams, Continuous cooling transformation diagram. Effect of alloying additions on TTT diagrams, Hardenability, its measurement and control; Heat treatment Furnaces and atmospheres.

UNIT-V **(10 Hrs)**

Annealing, Normalising, Hardening and Tempering, Austempering, Martempering, Sub-zero treatment, Patenting, Recovery, recrystallization and grain growth, Precipitation hardening; Surface Hardening methods: Thermal – flame hardening, induction hardening, and advanced techniques like plasma, electron beam etc.; Thermo-chemical processes – carburizing, nitriding, carbonitriding, ion implantation etc.

UNIT-VI **(10 Hrs)**

Heat treatment of special purpose steels: tool steels, high speed steels, maraging steels, HSLA steels and die steels; Heat treatment of cast irons: gray cast irons, white cast irons and S.G.irons, austempering of S.G.Iron; Heat treatment of non-ferrous alloys: aluminium alloys, copper alloys, nickel alloys and titanium alloys; Defects in heat treated parts: causes and remedies.

Learning resources Text book:

1. David A. Porter, K. E. Easterling and Md. Y. Sherif,, "Phase Transformations in Metals and Alloys" 3rd edition, 2009
2. T.V. Rajan, C.P. Sharma, Ashok Sharma, "Heat Treatment Principle and Techniques" 2nd edition, 2011 **Reference Books:**

1. Vijendra singh, "Heat Treatment of Metals , 2nd edition, 2006
2. Robert E. Reed hill, Reza Abbaschian, Lara Abbaschian,"Physical Metallurgy Principles" 4th edition, 2009.

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

1. Explain principle of phase transformation involved in the materials
2. Explain the formation of microstructure and development of mechanical properties in materials during heat treatment
3. Identify suitable heat treatment operation for materials according to applications

Assessment Method

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MM2103	Mechanical Behaviour and Testing of Materials	PCC	3-1-0	4

Course Objectives:

1. To explain concepts of stress and strain, analyze dislocation interactions with other defects.
2. To provide fundamental aspects of dislocation theories of plasticity behavior and various strengthening mechanisms
3. To study the various strengthening mechanisms
4. To introduce fracture mechanics
5. To study principles and equipment's of tensile, hardness and impact testings.
6. To understand phenomenon of creep and its testing**.**

Course Content:

UNIT I **(10 Hrs)**

Introduction: Strength of materials-Basic assumptions-elastic and plastic behaviour-Average stress and strain-concept of stress, strain and the types of stresses and strains. Dislocation theory: dislocation types, dislocation loop, dislocations in FCC, BCC and HCP, Stress fields and energies of dislocations forces on dislocations, forces between dislocation- Interaction of dislocations, dislocation multiplication, dislocation pileups, Interaction with points defects.

UNIT II **(10Hrs)**

Fracture: Elementary theories of fracture, Griffith's theory of brittle fracture, Ductile Fracture, Notch sensitivity. Hardness Test: Methods of hardness testing Brinells, Vickers, Rockwell, Rockwell superficial, Shore and Poldi methods, Microhardness test, relationship between hardness and other mechanical properties**.**

UNIT III **(10 Hrs)**

TENSION TESTING: ASTM Standards and specification, Engineering stress & strain, True stress strain curves, Holloman - Ludwig equation, Plastic Instability (Necking), Testing machines-types, testing procedures, properties measured, specimen dimensions, Problems. TORSION TESTING & SHEARING TEST: ASTM Standards and specification Testing Machines and procedures.

UNIT IV **(10 Hrs)**

Impact Test: Notched bar impact test and its significance, Charpy and Izod Tests, significance of transition temperature curve, Metallurgical factors affecting the transition temperature, temper

embrittlement. DBTT curve and its importance. Fracture toughness testing - COD and CTOD tests.

UNIT V **(10 Hrs)**

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

UNIT VI **(10 Hrs)**

Creep and Stress Rupture: Introduction, The creep curve, Stress-rupture test, Structural changes during creep, Mechanism of creep deformation, theories of creep. Fracture at elevated temperature, Effect of Metallurgical variables on creep. Wear: Classification and mechanisms of wear, delamination theory, debris analysis, testing methods

Learning resources

Text book:

1. George E Dieter, “Mechanical Metallurgy", McGraw Hill Education, Third edition, 2017.
2. Thomas H.Courtney, “Mechanical Behaviour of Materials”, McGraw-Hilll, Boston, 2nd edition, 2000. **Reference Books:**

1. Wullf et al, Vol. III “Mechanical Behavior of Materials", John Wiley and Sons, New York, 1983.
2. R.W. Hertzberg, "Deformation and Fracture Mechanics of Engineering Materials", John Wiley and Sons, 1976.
3. A .K. Bhargava, C. P. Sharma, “Mechanical behaviour and testing of materials”, PHI Learning, First edition, 2011.
4. Suryanarayana, A. V. K., “Testing of Metallic Materials”, Prentice Hall India, New Delhi, 1979
5. Marc A. Meyers, Krishan Kumar Chawla “Mechanical Behavior of Materials” Cambridge University Press, 2008

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

1. Use the concepts of stress and strain to explain the elastic and plastic behaviour of the material
2. Relate the mechanical behaviour of materials to dislocation theory and presence of crystal defects
3. Design a process based on strengthening mechanisms for a given application
4. Understand response of materials under different kinds of stresses, temperature and environment
5. Identify engineering problem in using plastic deformation, fatigue, fracture and creep

Assessment Method

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MM2104	**Engineering Polymers**	**PCC**	**3-0-0**	**3**

Course Learning Objectives:

1. To understand the polymer molecule in terms of its chain structure and, in addition, how the molecule may be generated from repeat units
2. To understand the number–average and weight–average molecular weights, and degree of polymerization
3. To learn synthesis, properties and applications of polymeric materials

Course Content:

Unit-I : (8 Hrs)

Introduction to polymers and plastics**;** Conception of polymers, formation of polymers, types of polymers reactions such as addition and condensation, Mechanism of polymerization - Thermoplastic and Thermosetting materials methods of polymerization.

Unit-II: (7 Hrs)

Polymeric structure, raw materials and properties; Classification of polymers, raw materials for polymers and their sources. Brief study of structure of polymers and properties. Glass transition temperature and its significance. Crystallinity of polymeric materials, effect of time, temperature, catalysts and solvents on polymer properties, molecular weight of polymers.

Unit-III: (8 Hrs)

Compounding and fabrication of plastics, calendaring and casting. Recycling of Plastics, Functions of the following types of additives used in Polymers. 1. Fillers 2. Lubricants 3. Reinforcing agents 4. Plastricizers 5. Stabilizers 6. Antioxidants 7. Inhibitors 8. Promoters 9. Catalysts 10. Refarders 11. Limitators 12. Colorants 13. Cross-linking 14. Blowing agents 15. Photo degradiants 16. Bio-degradiants, laminated polymers.

Unit-IV: (7 Hrs)

Thermoplastics**;** Methods of addition polymerization, raw materials, manufacturing methods, properties and uses of the following ethenoid polymers; Polyethene (LDPE and

HDPE), Polypropylene, Poly Vinyl Chloride, Polystyrene, Expanded polystyrene, Polytetra fluorethylene.

Unit-V: (8 Hrs) Thermosetting resins; Introduction of thermosetting polymers, methods of condensation polymerizatin, raw materials, manufacturing method, properties and uses of Phenol- Formaldehyde resin, Urea-formaldehyde resins, alkyl resins.

Unit-VI: (7 Hrs)

Raw materials, manufacturing methods, properties and uses of the following plastics Acetals, Nylons, Polymethyl, Methocrylate (PMMA), Saturated polysters – PETP and PC, Cellulose acetate and viscose rayon. Introduction of natural rubbers and synthetic rubbers like Buna-S, Buna-N, Thiokol, Polyurethane rubber and Silicon rubber.

Learning resources

Text book:

1. V.R. Gowariker, N.V. Viswanathan and Jayadev Sreedhar, “Polymer Science” New Age International (p) Ltd., New Delhi , 2010.
2. F.W. Bill Mayer, “Text book of polymer science” 3rd Edition – John Wiley & sons, Inc., New York, 2011.

Reference Books:

1. Raymond Seymour, "An Introduction to Polymer Chemistry", McGraw Hill, New York, 1971.
2. Charles A Harper, “Handbook of Plastics, Elastomers and Composites", McGraw Hill, USA, 1997.
3. McCrum N G, Buckley C P and Bucknall C B ,"Principles of Polymer Engineering", Oxford University Press, 1992.

Course outcomes:

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

1. Explain the structure and synthesis of different polymeric materials
2. Design process flow chart for fabrication of polymeric components
3. Select proper polymeric materials for engineering applications

Assessment Method

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total

Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MM2181	**Mineral Processing and Extractive Metallurgy Laboratory**	**PCCL**	**0-0-3**	**1.5**

List of Experiments

1. Study and observations of mineral samples
2. Sampling of an ore from the bulk by (i) Coning and quartering method (ii) Riffle sampler methods
3. Determination and analyze of the size distribution of a fixed granular solid by using a test sieve stack and a vibratory shaker.
4. Verification of Stoke's Law.
5. Determining the reduction ratio of a jaw crusher.
6. Study of the variation of reduction ratio with process variables in Rolls crusher.
7. Study of the process variables on reduction ratio and particle size distribution in ball mill.
8. Determination of the grindability index of ores.
9. Verification of Laws of Communution.
10. Determination of the efficiency of a magnetic separator.
11. Determination of the efficiency of a jig.
12. Study of the particle separation by fluid flow using wilfley table.
13. Determination of the efficiency of a pneumatic separator.
14. To study the concentration of metallic and non-metallic ores by Froth-Flotation process.

Assessment Method

Assessment Tool	Experiments	Record	Viva-Voce/ Quiz/MCQ/Lab project	Total
Weightage (%)	25%	5%	10%	40%

End Semester Examination weightage (%)	60%

Course Code	Course Name	Course Category	L-T-P	Credits
20MM2182	**Phase Transformations and Heat Treatment Laboratory**	**PCCL**	**0-0-3**	**1.5**

List of Experiments

1. Study of heat treating furnaces and atmosphere
2. Study of TTT and CCT diagrams
3. Annealing of medium carbon steel and observation of microstructure & hardness
4. Normalizing of medium carbon steel and observation of microstructure& hardness
5. Hardening of medium carbon steel and observation of microstructure &hardness
6. Study of tempering characteristics of hardened steel.
7. Spheroidizing of high carbon steel
8. Determination of hardenability of a given steel using Jominy end Quench Test
9. Study of age hardening phenomenon in an aluminum alloy or brass
10. Case Carburizing of low carbon steel and determination of case depth
11. Re-crystallization studies on cold worked copper or Cu – alloys

Assessment Method

Assessment Tool	Experiments	Record	Viva-Voce/Lab project	Total
Weightage (%)	25%	5%	10%	40%
End Semester Examination weightage (%)				60%

Course Code	Course Name	Course Category	L-T-P	Credits
20MM2183	**Mechanical Behaviour and Testing of Materials Laboratory**	**PCCL**	**0-0-3**	**1.5**

List of Experiments

1. Determination of the Brinell Hardness Values of Plain carbon steel and Aluminum alloy samples.
2. Determination of the Rockwell Hardness Values of Plain carbon steel and Aluminum alloy samples.
3. Determination of the Vickers Hardness Values of Plain carbon steel and Aluminum alloy samples.
4. Determination of Stress Strain Curve for AISI 1040 Steel and Identify elastic modulus, ultimate tensile strength, breaking stress, percentage elongation and percentage reduction in area.
5. Determination of Stress Strain Curve for Aluminum Alloy and Identify elastic modulus, ultimate tensile strength, breaking stress, percentage elongation and percentage reduction in area.
6. Determine the impact energy of given samples at different temperatures using Charpy impact tester and comment on the DBTT obtained.
7. Study of fatigue testing Machine and Determination of number of cycles to failure of a given material at a given stress.
8. Determination of creep behavior of lead at room temperature.
9. Determination of stiffness and modulus of rigidity of the spring wire.
10. Determination of wear coefficient of given materials

Assessment Method

Assessment Tool	Experiments	Record	Viva-Voce/ Quiz/MCQ/Lab project	Total

Weightage (%)	25%	5%	10%	40%
End Semester Examination weightage (%)				60%

Course Code	Course Name	Course Category	L-T-P	Credits
20BE2101	**Environmental Science**	**MC**	**2-0-0**	**0**

Course Learning Objectives:

1. To provide knowledge about multidisciplinary nature of environment, various sources of natural energy.
2. Understanding of ecosystem structure and function etc.
3. Knowledge of biodiversity and conservation
4. Understanding of problems caused by pollution and its impact
5. Understanding about the various social issues related to environment.
6. Awareness for the Environment and human health

Course Content:

UNIT-I: The Multidisciplinary Nature of Environmental Studies and Natural Resources (9 hours)

The Multidisciplinary Nature of Environmental Studies: Definition, scope and importance; Need for public awareness.

Natural Resources: Renewable and Non Renewable Resources Natural resources and associated problems.

a) Forest resources: Use and over-exploitation, deforestation, case studies. Timber extraction, mining, dams and their effects on forest and tribal people. b) Water resources: Use and overutilization of surface and ground water, floods, drought, conflicts over water, dams-benefits and problems. c) Mineral resources: Use and exploitation, environmental effects of extracting and using mineral resources, case studies. d) Food resources: World food problems, changes caused by agriculture and overgrazing, effects of modern agriculture, fertilizer-pesticide problems, water logging, salinity, case studies. e) Energy resources: Growing energy needs, renewable and non renewable energy sources, use of alternate energy sources. Case studies. f) Land resources: Land as a resource, land degradation, man induced landslides, soil erosion and

desertification. Role of an individual in conservation of natural resources. Equitable use of resoureces for sustainable lifestyles.

UNIT-II: Ecosystems (4 hours)

Concept of an ecosystem, Structure and function of an ecosystem, Producers, consumers and decomposers,Energy flow in the ecosystem,Ecological succession, Food chains, food webs and ecological pyramids,Introduction, types, characteristic features, structure and function of the following ecosystem:-a. Forest ecosystem, b. Grassland ecosystem, c. Desert ecosystem, d. Aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries).

UNIT-III: Biodiversity and It's Conservation (4 hours)

Introduction – Definition: genetic, species and ecosystem diversity, Biogeographical classification of India,Value of biodiversity: consumptive use, productive use, social, ethical, aesthetic and option values, Biodiversity at global, National and local levels, Inida as a megadiversity nation, Hot-sports of biodiversity, Threats to biodiversity: habitat loss, poaching of wildlife, man-wildlife conflicts, Endangered and endemic species of India, Conservation of biodiversity: In-situ and Ex-situ conservation of biodiversity.

UNIT-IV: Environmental Pollution (6 hours) Cause, effects and control measures of:-a. Air pollution, b. Water pollution, c. Soil pollution, d. Marine pollution, e. Noise pollution, f. Thermal pollution, g. Nuclear hazards, Solid waste Management: Causes, effects and control measures of urban and industrial wastes, Role of an individual in prevention of pollution, Pollution case studies, Disaster management: floods, earthquake, cyclone and landslides.

UNIT- V: Social Issues and the Environment (4 hours)

From Unsustainable to Sustainable development Urban problems related to energy, Water conservation, rain water harvesting, watershed management, Resettlement and rahabilitation of people; its problems and concerns. CaseStudies, Environmental ethics: Issues and possible solutions.• Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust. Case Studies. Wasteland reclamation, Consumerism and waste products, Environment Protection Act, Air (Prevention and Control of Pollution) Act, Water (Prevention and control of Pollution) Act, Wildlife Protection Act, Forest Conservation Act, Issues involved in enforcement of environmental legislation, Public awareness.

UNIT-VI: Human Population and the Environment (3 hours)

Population growth, variation among nations, Population explosion – Family Welfare Programme, Environment and human health, Human Rights, Value Education, HIV/AIDS, Women and Child Welfare, Role of Information Technology in Environment and human health, Case Studies.

Learning Resources

Text Book:

1. Erach Bharucha, '*Textbook of Environmental studies'*, UGC

Reference Books:

1. Clark RS, '*Marine Pollution'*, Clanderson Press, Oxofrd (TB).

2. De AK, '*Environmental Chemistry'*, Wiley Eastern Ltd.

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

CO1	Well understanding about their surrounding natural resources and their conservation
CO 2	Able to understand the ecosystem food chain and habitat.
CO 3	Develop the practices for conservation of biodiversity
CO 4	To well understand the pollution courses, impact and prevention from pollution
CO 5	Able to bring about an awareness of a variety of environmental concerns.
CO 6	It attempts to create a pro-environmental attitude and a behavioral pattern in society that is based on creating sustainable lifestyles.

For Theory Courses Only:

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MM2201	Transport Phenomena in Materials	PCC	3-0-0	3

Course Objectives:

1. To introduce the concepts of fluid flow, heat transfer and mass transfer
2. To learn the fundamental connections between the conservation laws in heat, mass, and momentum transfer
3. To obtain the basic skills essential for process modeling of materials processing **Course Content:**

UNIT I

Properties of fluids, types of fluid flow, viscosity of liquid and gases, laminar flow, momentum balance general momentum equation (GME) and its application in flow of falling film, flow through a circular tube, flow between the parallel plates, application of Navier Stokes Equations

UNIT II

Turbulent flow: friction factors, flow past submerged bodies, flow through packed bed of solids, fluidized bed; Energy balanced application in fluid flow: conservation of energy, flow through valves and fitting, flow from ladles.

UNIT III

Steady state and Transient conduction in solids, One dimensional steady state problems of heat flow through composite walls, cylinder and spheres, Unsteady conduction in one dimensional system, Use of Heisler charts and applications; Convective heat transfer, equation of energy, free and forced convections.

UNIT IV

Radiation, Nature of thermal radiation, Black and Grey bodies, Stefan and Boltzmann law, Kirchhoff's laws, Intensity of radiation, lamberts law, View factor, Heat transfer between two black walls in an enclosure; Combined effect of convection, conduction and radiation, Overall heat transfer coefficient; Important application of steady heat flow in Metallurgy.

UNIT V

Mass Transfer: Fundamentals of diffusion; rate laws, Uphill diffusion and Kirkendal's effect, steady and unsteady diffusion, Numerical problems on diffusion mass transfer, Fundamentals of convective mass transfer; Problems on Convective mass transport, Application of mass transfer in: case hardening, doping of semiconductors, homogenization, oxidation.

UNIT VI

Dimensionless analysis: Rayleigh's method, Buckingham method, use of differential equations, Similarity criteria; Reaction Kinetics: Basic definitions and concepts, reaction mechanisms, reaction rate theories

Learning resources

Text book:

1. David R. Gaskell, "An Introduction to Transport Phenomena In Materials Engineering", Momentum Press; 2nd edition, 2012
2. K. Mohanty, "Rate Processes in Metallurgy" PHI Learning Pvt. Ltd., 3 edition, 2009

Reference Books:

1. N.J. Themelis, "Transport and Chemical Rate Phenomena", Gordon and Breach Publishers, New York, 1995.
2. R. Byron Bird, Warren E. Stewart and Edwin N. Lightfoot, "Transport Phenomena", John Wiley, 2012.
3. D. R. Poirier and G. H. Geiger, "Transport Phenomena in Materials Processing", John Wiley & Sons, 2010

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

1. Formulate conservation statements in heat, mass, and momentum at multiscales from microscopic to macroscopic in both steady and unsteady modes
2. Apply knowledge of mathematics and physics to transport phenomena related to materials processing
3. Design materials processing (e.g., leaching, casting, welding, heat treating, electrolyzing, etc.) based on transport phenomena

Assessment Method

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MM2202	Iron making Technology	PCC	3-0-0	3

Course Learning Objectives:

1. To learn construction features of blast furnace
2. To learn raw materials, their properties and it's testing for Iron making.
3. To understand the preparation of burden for Iron making
4. To study thermodynamics of reactions involved in iron making
5. To study recent developments in Blast Furnace practice
6. To learn alternative routes of iron making

Course Content:

Unit-I :

History of Iron making; Principles of Iron Making: Reduction, Smelting, Direct Reduction, Smelt Reduction; Blast furnace: Constructional features, Profile, Refractories, Accessories, Charging mechanism, Gas cleaning system, Hot blast generation, Cooling system.

Unit-II:

Occurrence and distribution of raw materials (iron ore, coal and flux) for iron making; Iron ore: properties, types, beneficiation, sizing, valuation; Fuels: Classification of fuels (solid, liquid and gas), their processing and their importance in blast furnace. Coking of coal, coal washing. Testing of coke for blast furnace. Problems of metallurgical grade coke in India and recent developments in coke making and blending; Principles of theory of combustion, combustion calculation, waste heat utilization; Fluxes and their Evaluation

Unit-III:

Agglomeration of Iron ore fines, Sintering: Principles, Factors affecting sintering, sintering mechanism, sintering machines; Pelletisation: Theory of pelletisation, Water-particles

system. Production of green pellets; disk and drum pelletizers, Induration of pellets: Shaft and traveling grate; Quality demands for the blast furnace burden.

Unit-III:

Physical, thermal and chemical profiles, physical chemistry of blast furnace reactions - carbon-oxygen reaction, gas-solid reactions in different zones of blast furnace, slag-metal reactions, kinetics of reduction, thermal efficiency, desulphurization and desiliconisation, mass and energy balances, Gruner's theorem, RAFT calculation, the Rist diagram.

Unit-V:

Process Developments: Fuel injection, Oxygen injection, High top pressure, High temperature blast, their effect on coke rate and metal-impurity distribution in slag and metal; Operations: Operational steps, Blast furnace irregularities and remedial measures, Blast furnace gas, properties, cleaning and utilization.

Unit-VI:

Idea about direct reduction process – DRI, HBI; Principles and technology of different coal based and gas based direct reduction processes like Rotary kiln, Rotary hearth, Midrex, HyL etc.; Concept of other smelting reduction processes like Corex, Romelt, HiSmelt, Finex etc., Advances in iron making.

Learning resources

Text book:

1. Tupkary, R. H. & Tupkary V.R., "An Introduction to Modern Iron Making", Khanna Publishers, New Delhi, 2004.
2. Ahindra Ghosh and Amit chatterjee, "Iron Making and Steel Making – Theory and Practice", Prentice Hall of India Private Ltd., New Delhi 2008.

Reference Books:

1. Biswas, A. K., "Principles of blast furnace iron making: theory and practice", SBA Publications, Kolkata, 1994.
2. Dipak Mazumdar, "A First Course in Iron and Steel Making", Orient Blackswan Private Limited - New Delhi, 2015
3. Bashforth R, "Manufacture of Iron and Steel Making", MIR Publishers, 1983.

Course outcomes:

1. At the end of the course, the student will be able to
2. Gain the knowledge on production of Iron
3. Discuss constructional features of Blast furnace and its design

4. Analysis the characteristics of raw materials required for Iron making
5. Design process flow chart for Iron making
6. Identify and solve the problems in blast furnace iron making

Assessment Method

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MM2203	**Metal Forming**	**PCC**	**3-0-0**	**3**

Course Learning Objectives:

1. To learn theory of elasticity and plasticity
2. To understand the principles of mechanical working of metal
3. To study process equipment and parameters involved in Bulk metal forming and sheet metal forming
4. To study the causes and remedies of different metal forming defects **Course Content:**

UNIT I

Stress and Strain Relationship for Elastic Behavior: Description of stress at a point. State of stress in two dimensions. Mohrs circle of stress in two dimensions, state of stress in three dimensions. Mohrs circle of stress in three dimensions. Description of strain at point.

UNIT II

Elements of Theory of Plasticity: The flow curve. True stress and true strain. Von-Mises distortion energy criterion, maximum shear stress or Tresca criterion. Octahedral shear stress and shear strain. Basics of the theories of plasticity.

UNIT III

Fundamentals of Metal Working: Classification of forming processes, Mechanics of metal working for slab method and uniform deformation energy method. Cold working, Recovery, recrystallization and grain growth, hot working, Strain-Rate effects, Work of plastic deformation.

UNIT IV

Forging: Classification of forging processes, forging equipment. Forging in plane strain. Opendie forging, closed-die forging, Forging of a cylinder in plane-strain. Forging defects. Rolling of Metals: Classification of rolling process, rolling mills. Hot rolling, cold rolling, rolling of bars and shapes, forging and geometrical relationships in rolling. Simplified analysis of rolling load, rolling variables, problems and defects in rolled products. Theories of hot rolling, torque and horsepower, theories of cold rolling, torque and horsepower.

UNIT V

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

UNIT VI

Drawing of Rods, Wires and Tubes: rod and wire drawing, tube drawing processes, deep drawing, residual stresses in rod, wire and tubes. SHEET METAL FORMING: Bending, wrap forming, spinning, stretch forming, deep drawing. Forming methods-rubber forming, shearing, blanking, bending, stretch forming, deep drawing, forming limit diagram, defects and application. **Learning resources**

Text book:

1. Dieter G E, “Mechanical Metallurgy”, McGraw Hill Co., 2001.
2. Surender Kumar “Technology of metal forming processes” PHI Learning, 2008.

Reference Books:

1. W. F. Hosford and R. M. Caddell, “Metal Forming: Mechanics and Metallurgy”, Cambridge University Press, 2007
2. K. Lange, “Handbook of Metal Forming”, SME, 1985.
3. ASM “Metals Handbook, Vol. 14, Forming & Forging”, ASM, Metals Park, Ohio, USA, 1998.
4. P. N. Rao, “Manufacturing Technology - Vol.1” McGraw Hill Education; Fifth edition, 2018

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

1. Explain theory involved in metal forming processes
2. Design a process flow chart for fabrication of metals through mechanical working operations
3. Able to calculate process load for given metal forming operations
4. Identify metal forming defects and suggest suitable remedies.

Assessment Method

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MM2204	**Corrosion Engineering**	**PCC**	**3-0-0**	**3**

Course Learning Objectives:

1. To study fundamentals of electrochemistry
2. To study different forms of corrosion and its mechanisms
3. To learn different testing methods involved for analysis of corrosion and monitoring
4. To know different methods of corrosion production
5. To study degradation of non-metallic materials **Course Content:**

UNIT I

Concept of Degradation process – Mechanical and chemical process, Importance of corrosion, Classification of corrosion, Electro-chemical principles and aspects of corrosion, Faradays laws, corrosion rate expression, thermodynamic aspects of corrosion, equilibrium potential, Nernst equation for electrode potential, EMF and Galvanic series, Pourbaix diagram (Fe)

UNIT II

General corrosion-atmospheric corrosion, galvanic corrosion, general biological corrosion; Localized corrosion-filiform corrosion, crevice corrosion, pitting corrosion, localized biological corrosion; Metallurgically influenced corrosion-inter granular corrosion, dealloying; Mechanically assisted corrosion-erosion corrosion, cavitation corrosion, fretting corrosion, corrosion fatigue, environmentally induced cracking-mechanisms of stress corrosion cracking and hydrogen embitterment.

UNIT III

Corrosion current density and corrosion rate, Exchange current density, over potential– polarization-activation and concentration polarization-Tafel equation, mass transport control, mixed potential theory and behaviour of galvanic couples in acidic environments, effect of oxidizer, combined polarization, factors affecting polarizations and rate of corrosion, Passivitypotentiostatic polarization curves, factors affecting passivity, mechanism of passivators.

UNIT IV

Electrochemical polarization techniques, Tafel extrapolation, linear polarization, AC impedance methods- electrochemical impedance spectroscopy. Corrosion Monitoring: Onstream monitoring-electrical resistance, linear polarization, hydrogen test probe, ultrasonic testing, radiography and corrosion coupons.

UNIT V

Factors affecting Corrosion: Environmental variables and Metallurgical variables; Prevention: corrosion control-design, selection of materials-alloying-stainless steel and brass, oxidation resistant materials-control of high temperature oxidation, cathodic and anodic protection methods, corrosion inhibitors-types, applications, corrosion in cold water pipes, galvanizing, painting and coating.

UNIT VI

Introduction to high temperature corrosion, Pilling Bedworth Ratio, oxidation kinetics, oxide defect structures, Wagner-Hauffe valence approach in alloy oxidation, Catastrophic oxidation, Internal oxidation, considerations in high temperature alloy design, prevention of high temperature corrosion- use of coatings, molten salt corrosion, liquid metal corrosion.

Learning resources

Text book:

1. Fontana M. G., “Corrosion Engineering”, McGraw Hill Education, 2nd Edition, 2017
2. Raj Narayan. “An Introduction to Metallic Corrosion and its prevention”, Oxford &BH, New Delhi,1983.
3. Denny Jones, “Principles and Prevention of Corrosion”, Prentice Hall of India, 1996.

Reference Books:

1. ASM Metals Handbook. Vol.l3,”Corrosion”. ASM Metals Park. Ohio. USA. 1994
2. Hihara L.H. and Adler R.P.I., Environmental Degradation of Advanced and Traditional Engineering Materials, CRC Press,2012
3. Pierre R. Roberge, “Corrosion Engineering principle and practice” McGraw Hill Inc., 2008.

4. Kenneth R Trethewey and John Chamberlain, "Corrosion for Science and Engineering", Longman Inc., 1996.
5. Herbert H. Uhlig, R. Winston Revie “Corrosion and Corrosion Control: An Introduction to Corrosion Science and Engineering” 4 th Edition, John Wiley & Sons, Inc., 2008

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

1. Identify types and mechanism of corrosion in engineering problems
2. Test the materials for corrosion behavior
3. Suggest the suitable corrosion prevention method to improve life of materials

Assessment Method

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MM2205	**Science and Technology of Ceramics**	**PCC**	**3-0-0**	**3**

Unit 1:

Applications of ceramics, classification of ceramics,fine ceramics, Introduction: oxide and non-oxide ceramics, their chemical formulae, Rules for structure formation in oxides/ionic solids, Crystallography: structures and structure determination, Atomic structure and bonding in materials.

Unit 2:

Review of Bonding Characteristics of Ceramics (Madelung Constant, Born-Haber Cycle, Non-Bonding Electron Effects, Crystal Field Effect, Jahn-Teller Distortion) Crystal structure of materials, crystal systems, unit cells and space lattices, determination of structures of simple crystals by x-ray diffraction, miller indices of planes and directions, packing geometry in metallic, ionic and covalent solids. Concept of amorphous, single and polycrystalline structures and their effect on properties of materials.

Unit 3:

Defects and dislocations in ceramics,non-stoichiometry and typical properties, Defects equilibrium, Defects diffusion, Ionic and defect conductivity, Electronic properties of ceramics

Unit 4:

Powder Preparation: Physical methods (different techniques of grinding), chemical routes - coprecipitation, sol-gel, hydrothermal, combustion synthesis, high temperature reaction (solid state reaction).

Unit 5:

Basic principles and techniques of consolidation and shaping of ceramics: powder pressing-uniaxial, biaxial and cold isostatic and hot isostatic, injection moulding, slip casting, tapecasting, calendaring, multilayering.

Unit 6:

Ceramics for energy and environment technologies (fuel cell, lithium battery, gas sensor and catalytic support)

TEXT BOOKS;

1. Introduction to Ceramics – W.D. Kingery et al – John Wikey
2. FINCER proceedings of workshop on fine ceramics synthesis, properties and applications – T.R. Rammohan et al.
3. Materials Science and Engineering, An introduction. WD Callister, Jr., Adapted by R. Balasubramaniam, John Wiley & Sons, NY, Indian edition, 2007

REFERENCE;

1. Hand Book of Fibre-reinforced composite materials - Ed. Lubin.
2. Fundamentals of Ceramics – M W Barsoum
3. Ceramics – Mechanical Properties, Failure Behaviour, Material Selection – D. Munz & T. Fett
4. Ceramic Science and Technology – Vol. 2 Material Selection and Properties Ed., Ralf Riedel and I –Wei Chen, Wiely -VCH

Assessment Method

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MM2281	**Metal Forming Laboratory**	**PCC**	**0-0-3**	**1.5**

List of Experiments

1. Determination of n and K values using tension test
2. Verification of hall-Petch relation in mild steel specimens.
3. Formability of sheet metal by Ericsson cupping test
4. Determination of friction coefficient using ring compression test
5. Cold working of low and high stacking fault energy materials
6. Effect of cold working on mechanical properties (Hardness) of copper and steel
7. Annealing of cold worked metals and alloys
8. To manufacture washer components using fly press (progressive dies /compound dies)
9. Deep drawing of a cup with / without blank holder by hydraulic press
10. To demonstrate the effect of friction and height-to-diameter ratio in the axisymmetric compression of a cylinder.
11. To analyze the load and metal flow in extrusion with different friction conditions and semi-die angles.
12. Determine Green Density and Strength Characteristics (hardness) of Coldcompacted and sintered (Conventional) compact of Copper Powder

Assessment Method

Assessment Tool	Experiments	Record	Viva-Voce/ Quiz/MCQ/Lab project	Total
Weightage (%)	25%	5%	10%	40%
End Semester Examination weightage (%)				60%

Course Code	Course Name	Course Category	L-T-P	Credits
20MM2282	Corrosion Engineering Laboratory	PCC	0-0-3	1.5

List of Experiments

1. Study the effect of concentration and temperature on conductivity of an aqueous electrolyte (Aq. NaCl).
2. Verification of Faraday's laws.
3. Determination of corrosion rate by weight loss method
4. Determination of corrosion rate by electro-chemical method
5. Perform and observe the corrosion phenomenon of (a) Stress Corrosion Cracking in Brass/Mild Steel, (b) Crevice Corrosion of Stainless steel in chloride solution, (c) Pitting of Stainless Steel.
6. Study the effect of passive film for the systems of (a) Al in $CuSO_4$ Solution, (b) Stainless Steel in HNO_3
7. Perform electrolytic deposition (copper plating and nickel plating) and study effect of parameters.
8. Anodize the given aluminium sample and colour with a dye and to measure the thickness of the oxide film
9. Understand the principles in galvanic cell corrosion using "Ferroxyl" indicating test solution.
10. Conduct electropolishing of stainless steel using Nitric acid batch
11. Study the effect of inhibitors on corrosion
12. Determination of film stability of industrial protective coatings on metal sheet substrates to salt spray.
13. Corrosion studies of Copper sample by using Scanning Electron Microscope.

Assessment Method

Assessment Tool	Experiments	Record	Viva-Voce/ Quiz/MCQ/Lab project	Total
Weightage (%)	25%	5%	10%	40%
End Semester Examination weightage (%)				60%

Course Code	Course Name	Course Category	L-T-P	Credits
20MM3101	Materials Characterization	PCC	3-1-0	4

Course Learning Objectives:

1. To obtain knowledge on various structural and microstructural characterization techniques of materials.
2. To study the principles, theory and practice of various characterization techniques.

Course Content:

Unit-I : **(10 Hrs)**

Introduction, concept of resolution, Airy rings, numerical aperture, magnification, depth of field, depth of focus, lens defects and their corrections, principles of phase contrast – bright-field and dark-field contrast, polarized light microscopy, Quantitative microscopy, estimation of grain size, grain boundary area, relevance of light microscopy ideas to electron microscopy.

Unit-II: **(10 Hrs)**

Introduction, crystal geometry, lattice directions and planes, zone axis, interplaner spacing and angle, Stereographic projection, Bragg's condition of diffraction, X-ray scattering, application of X-ray diffraction – phase identification, estimation of grain size, particle size, residual stress.

Unit-III: **(10 Hrs)**

Principle, construction and operation of TEM, Interaction of electrons with specimen, reciprocal space and lattice, Ewald sphere, diffraction from finite crystal, preparation of specimens, bright and dark field imaging, selected area diffraction, indexing of diffraction patterns.

Unit-IV: **(10 Hrs)**

Construction and working principle of SEM. Resolving power, magnification, depth of field, depth of focus, image contrast, Secondary electron, back scattered mode of imaging and energy dispersive analysis of x-rays, Sample preparation techniques.

Unit-V: **(10 Hrs)**

Scanning Tunneling Microscopy (STM) & Atom Force Microscopy (AFM), Scanning Transmission electron Microscopy (STEM)

Unit-VI: **(10 Hrs)** Principles of differential scanning calorimetry (DSC), differential thermal analysis

(DTA), Dilatometry, Thermogravimetric analysis (TGA), Dynamic mechanical anaylsis, ThermoMechanical Anaylsis.

Learning resources

Text book:

1. P. J. Goodhew, J. Humphreys, R. Beanland, "Electron microscopy and analysis", CRC Press, 3rd edition, 2000.
2. B.D. Cullity, S.R. Stock, "Elements of X-Ray Diffraction", Pearson; 3 edition, 2001.
3. Brown, M.E., "Introduction to Thermal Analysis: Techniques and Applications", Springer-Verlag New York Inc.; 2nd edition, 2001

Reference Books:

1. P.J. Grundy and G.A. Jones, "Electron Microscopy in the Study of Materials", Hodder & Stoughton Educational, 1976.
2. D.B. Williams and C.B. Carter, "Transmission Electron Microscopy", Springer; 2nd edition, 2009.
3. C.S. Suryanarayana, and M. Grant Norton, "X-ray Diffraction: A Practical Approach",
4. Springer, 2013.
5. D.A. Skoog, F.J. Holler and S.R. Crouch, "Principles of Instrumental Analysis", Thomas Brookes/Cole, 6th Edition, 2007

Course outcomes:

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

1. Determine crystal structures of materials
2. Analyse microstructure of materials at different length scales
3. Analyse defects and fracture surfaces of the tested materials
4. Indicate instrumentation associated with and operating principles of various techniques

Assessment Method

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MM3102	Solidification Process and Casting	PCC	3-1-0	4

Course Learning Objectives:

1. To learn different methods and materials of moulding and pattern making
2. To familiarize with different casting techniques
3. To study the principles of solidification and microstructure formation during casting process
4. To understand casting hydrodynamics and heat transport
5. To familiarize with casting practice of different alloys.

Course Content:

Unit-I : (12 Hrs)

Introduction: Foundry as a manufacturing centre, Scope and development of foundry, Types of foundries; Pattern: Types of patterns, Pattern materials, Pattern allowances, Pattern layout, Pattern making; Moulding and Core Making:Types of moulding equipment, Moulding materials, Moulding sands, Properties and selection of materials and additives used, Core and core making; Testing of Foundry Sand: Strength, Permeability, Moisture content, Shatter Index, Mouldability, Compactability, Loss on ignition, Clay content, AFS grain fineness number.

Unit-II : (12 Hrs)

Green sand moulding process, Dry sand moulding process, CO2 moulding process, No bake moulding process, Shell moulding process, Investment casting, Permanent moulding, Pressure die casting, Gravity die casting, Continuous casting, Electroslag casting, Squeeze casting, Slush casting, Thixocasting and rheocasting processes, Cosworth process, Magnetic moulding, Impulse moulding, High pressure moulding, Vacuum sealed moulding process.

Unit-III : (12 Hrs)

Thermodynamics of solidification: liquid phase, cooling curve analysis of pure metal and alloy, thermal undercooling, molar free energy; Kinetics of solidification: nucleation phenomena, homogeneous nucleation, heterogeneous nucleation, nucleating sites and agents, controlled nucleation, dynamic nucleation; Growth during solidification: structure of the Interface, normal growth, growth by surface nucleation, growth on imperfections; formation of planar, cellular, dendritic and equiaxed structures; Solidification of alloys: short range and long range solidifying alloys, constitutional undercooling, eutectic growth,

factors influencing freezing and control of alloy constituents; Solidification defects: segregation, shrinkage, porosity, hot tears, cold cracks.

Unit-IV : (10 Hrs)

Fluid dynamics: Fluidity, measurement of fluidity, effects of various parameters on fluidity, capillary flow, feeding mechanisms, centreline feeding resistance, principles of fluid flow; Gating: elements of gating system and their characteristics, aspiration of gases in gating system, filling time calculation, design of gating system, pouring basin, spure, sprue base well, runner, ingates; slag trap and filters, gating ratios

Unit-V : (10 Hrs)

Heat transport: solidification in sand mold, solidification in metal mold; Risering: risering practice, blind and atmospheric risers, riser size and location, risering curves, caine's method, NRL method and modulus methods, feeding distance, optimum risering practice, feeding aids, chills, padding.

Unit-VI : (4 Hrs)

Analysis of Casting defects: Surface defects, Discontinuity, Dimensional defects, Internal defects; **Learning resources**

Text book:

1. Peter Beelay, "Foundry Technology", Butterworth-Heinemann, 2001.
2. Ramana Rao T.V. "Metal Casting Principles and Practice", New Age International (P) Limited, 2003.
3. Jain.P.L. "Principles of Foundry Technology" Tata McGraw- Hill Publishing Co., Ltd, 1995.

Reference Books:

1. Flinn, R.A. "Fundamentals of Metal Casting", Addison – Wesley, 1963.
2. Srinivasan, N. K. "Foundry Technology" Khanna Publications, 2001.
3. Heine, R. W. Loper, C.R. and Rosenthal, P.C. "Principles of Metal Casting" Tata McGraw Hill Publishers, 2003.
4. A. K Chakrabarti, "Casting Technology and Cast Alloys", PHI, 2008
5. K C John, "Metal Casting & Joining" PHI, 2015
6. P. C. Mukherjee, "Fundamentals of Metal casting Technology", Oxford IBH, 1980.

Course outcomes:

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

1. Select proper materials and methods for moulding, pattern making for different products
2. Design gating and risering systems
3. Choose correct melting furnace and melting practice for different casting metals and alloys.

4. Analyze the irregularities and cause of defects in castings and apply the remedial measures for immediate rectification
5. To design moulds and pattern for making castings, to inspect a casting

Assessment Method

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MM3103	**Non Ferrous Extractive Metallurgy**	**PCC**	**3-0-0**	**3**

Course Learning Objectives:

1. To learn principles of different extraction methods
2. To study process flow and parameters involved in extraction of different nonferrous metals

Course Content:

Unit-I : **(7 Hrs)**

Early developments in metal extraction- Sources of nonferrous metals- Principles of metals extraction: Thermodynamic principles, homogeneous and heterogeneous reactions, Ellingham diagrams, kinetic principles, principles of electro-chemistry

Unit-II : **(8 Hrs)**

General methods of extraction :Pyrometallurgy – calcinations ,roasting and smelting, Hydrometallurgy – leaching, solvent extraction, ion exchange, precipitation, and electrometallurgy – electrolysis and electro-refining, General methods of refining: Basic approaches, preparation of pure compounds, purification of crude metal produced in bulk

Unit-III : **(8 Hrs)**

Extraction of metals from oxide sources: Basic approaches and special features of specific extraction processes, extraction of metals such as magnesium, aluminum, tin and ferro-alloying elements, production of ferro alloys.

Unit-IV : **(8 Hrs)**

Extraction of metals from sulphide ores: Pyro-metallurgy and hydro-metallurgy of sulphides, production of metals such as copper, lead, zinc, nickel.

Unit-V : **(8 Hrs)**

Extraction of metals from halides: Production of halides and refining methods, production of reactive and reactor metals. Methods of extraction of metals such as titanium,rare earths, uranium, thorium, plutonium, beryllium, zirconium.

Unit-VI : **(6 Hrs)**

Production of precious metals : Methods applied for gold, silver and pt. group of metals, Secondary metals and utilization of wastes,Energy and environmental issues in nonferrous metals extraction

Learning resources

Text book:

1. Ray H S, Gosh A, "Principles of Extractive Metallurgy", New Age international Publishers, 2007.
2. Ray H. S., Sridhar R., Abraham K. P, 'Extraction of Non- ferrous Metals', Affiliated East West Press, 2008 **Reference Books:**

1. Rosenquist T., 'Principles of Extractive Metallurgy', 2nd Edition McGraw Hill, 1983
2. Raghavan R., "Extractive Metallurgy of Non-Ferrous Metals", Vijay Nicole Imprints, 2015.
3. Bray J.L., "Extraction of Non-ferrous Metals", John Wiely & Sons, 1959
4. R.D. Pehlke, "Unit processed in extractive metallurgy", American Elsevier Pub. Co., 1973.

Course outcomes:

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

1. Explain process flow-sheet for an nonferrous extractive process.
2. Analysis and interpret significance of the results for the extraction of nonferrous metals like Al, Cu, Mg, Sn, Ni, Zn, Ag, Au, Pb etc.

Assessment Method

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MM3104	Semiconductor Materials	PCC	3-0-0	3

Course Content:

Unit-I

Semiconducting materials – History and its relevance in modern world, types of semiconductors, elemental semiconductors, Formation of energy bands in solids, Concept of hole, Density of states and Fermi level, Intrinsic and extrinsic semiconductors

Unit-II

Equilibrium Carrier concentration, Recombination and Generation of carriers, Carrier transport – Drift and Diffusion, Equations of state – Continuity and Poisson equation, formation of pn junction – energy band diagrams of –pn junction, BJT, MOS Capicitor

Unit-III

Introduction to compound semiconductors & alloys, commonly used compound semiconductors, outline of the crystal structure, dopants and electrical properties such as carrier mobility

Unit-IV

Band gap engineering, direct and indirect band gap semiconductors, optoelectronic applications such as LEDs, LASERS

Unit-V

General Overview of Organic Semiconductors - Electronic transport in crystalline organic materials and conductive polymers - basics of Molecular Quantum electronics - Optical and Electrical Properties of Organic Semiconductor Material

Unit-VI

Processing and Fabrication of organic semiconductors: Spin coating, Evaporation, Sputtering, Electrospinning, Drop casting, Templating

Learning resources

Text book:

1. Semiconductor devices: Physics and Technology, S. M. Sze, Wiley India Private Limited.
2. Semiconductor Optoelectronic Devices, Pallab Bhattacharya, Pearson.
3. R.E. Hummel; Electronic Properties of materials.
4. Suganuma Katsuaki, Introduction to Printed Electronics, Springer, 2014 **Assessment Method**

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L – T - P	Credits
20MM3105	**Steel Making Technology**	**PCC**	**3-0-0**	**3**

Course Learning Objectives:

1. To learn important raw materials required for steelmaking and earlier steel making practices.
2. To learn thermodynamics and kinetics involved in production of steel
3. To provide the knowledge on production of steel through various technologies
4. To understand different secondary steel making practices to produce quality steel 5. To study continuous casting practices

Course Content:

Unit-I :

Steel scenario-Global and Indian, Raw materials for steel making, Factors affecting efficiency of steel making, Earlier steel making processes: Bessemer, OH, Kaldo, Rotor processes, Reasons for their extinction, Development of Twin Hearth process. Concept of mini and integrated steel plant.

Unit-II:

Physical chemistry of carbon, silicon, manganese, phosphorus and sulphur reaction; Slags: their constitution and properties and the theories predicting their behavior, Control of nitrogen and hydrogen in steel, Deoxidation practice, Desulphurization techniques.

Unit-III:

BOF practice, Equipment, Operation and Process, slag Metal reactions in B.O.F., Raw material and flux practices, Modifications and further Development in Conventional BOF, Oxygen Lance: Design, Construction and Operation, Top and Bottom Blown processes, Its advantages and disadvantages.

Unit-IV:

Arc and Induction furnace: merits and limitations; Electric Arc furnace (EAF): mechanical and electrical components, transformer rating and furnace capacity, refractory practices, raw material selection and melting practice; Induction furnace (IF): principle, type, construction, refractory lining and melting practice; Furnace practices for Carbon and Low Alloy Steels.

Unit-V:

Clean steel, Stirring techniques- ladle metallurgy, Vacuum treatments & Decarburizing techniques: Argon oxygen decarburization (AOD), Vacuum oxygen decarburization (VOD), degassing processes (RH & REDA process),Vacuum Induction Melting (VIM),
Post solidification treatments: Vacuum Arc Re-melting (VAR), Electro slag Re-melting (ESR), Injection metallurgy, Secondary refining furnaces (Ladle and SKF furnaces).

Unit-VI:

Casting pit side practice, Types of Moulds, Teeming Methods, Killed, Semi Killed, and rimmed Steels, Solidification of steels. Ingot defects and remedies; Continuous casting practice; factors affecting heat transfer in contiguous casting practice; defects.

Learning resources

Text book:

1. Ahindra Ghosh and Amit Chatterjee, “Iron Making and Steel Making-Theory and Practice”, PHI, New Delhi 2010.
2. Tupkary R J, “An Introduction to Modern Steel Making", Khanna Publishers, New Delhi, 2010.

Reference Books:

1. A.K. Chakrabarti, “Steel Making”, Prentice-Hall of India Pvt. Ltd, 2005
2. Bashforth R, “Manufacture of Iron and Steel Making”, MIR Publishers, 1983.
3. Fruehan R J “The Making, Shaping and Treating of Steel: Steel Making and Refining", The AISE Steel Foundation, 1999.
4. Turkdogan E T, “Fundamentals of steel making” Maney Publishers, 2010.
5. Dipak Mazumdar, James W Evans, “Modeling of steel making process” CRC Press, 2009.

Course outcomes:

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

1. Classify different kinds of furnaces and their ancillary equipments used for Steel making
2. Analyze the irregularities and cause of failures in production of steel and apply the remedial measures for immediate rectification
3. Design the treatment to the liquid steels for attaining better properties.
4. Apply the physical chemistry concept to explain new developments in steel making industry

Assessment Method

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MM3181	**Materials Characterization Laboratory**	**PCC**	**0-0-3**	**1.5**

List of Experiments

1. Quantitative image analysis of phase fraction, grain size, nodularity and nodule count.
2. Calculation of structure factor of different crystal structures.
3. Determination of crystal structure by X-ray Diffraction (XRD)
4. Determination of lattice parameter by XRD
5. Determination of crystallite size by XRD
6. Determination of lattice strain of a deformed sample using XRD
7. Fractography analysis using Scanning electron microscopy (SEM)
8. Determination of interlamellar spacing of pearlite using SEM
9. Chemical analysis using energy dispersive X-ray analysis in SEM (spot and line analysis).
10. Study of Wulff net diagram, Stereographic projection & Pole Figures
11. Study of DSC, TGA and FTIR. **Assessment Method**

Assessment Tool	Experiments	Record	Viva-Voce/ Quiz/MCQ/Lab project	Total
Weight age (%)	25%	5%	10%	40%
End Semester Examination weight age (%)				60%

Course Code	Course Name	Course Category	L-T-P	Credits
20MM3182	**Solidification Process and Casting Laboratory**	**PCC**	**0-0-3**	**1.5**

List of Experiments

1. Study of cooling curves of pure metal and alloys.
2. Study of Foundry tools
3. Determination of sand fineness number and distribution of the dry sand.
4. Determination of moisture content of the green sand
5. Determination of flowability and compactibility of green sand
6. Determination of permeability of the green sand with varying clay and moisture content.
7. Determination of the variation of sand properties like green hardness, green compact strength with additives in sands.
8. Determination of the variation of hot compact hardness and hot shear strength with additives in sands.
9. Determination of clay content in sand.

10. Determination of the shatter index of green sand.
11. Preparation of green sand mould using given split pattern.
12. Study of different melting furnaces.
13. Melting and Casting of Al alloys

Assessment Method

Assessment Tool	Experiments	Record	Viva-Voce/ Quiz/MCQ/Lab project	Total
Weightage (%)	25%	5%	10%	40%
End Semester Examination weightage (%)				60%

Course Code	Course Name	Course Category	L-T-P	Credits
20EG3182	**English Language Communication Skills Lab-II**	**HSC**	**0-0-3**	**1.5**

Course objectives:

1. To improve group discussion skills of the students
2. To help the students to write their CV and Internship application
3. To improve the telephonic etiquettes of the students
4. To help the students to take decision on their career

Course Content:

Unit-I **(06 Contact Hours)**

Group Discussion - How to think and analyze - How to initiate a topic - How to continue a topic - How to support or reject a point-of-view - How to defend your position - Managing distractions and mediating between contenders - How to summarize & conclude

Unit-II **(06 Contact Hours**

Telephonic conversation & Etiquettes - How to introduce oneself - How to introduce the main issue - How to keep the other person engaged - How to convince the other person - How to complain without irritating. - Giving assurance and asking for clarification - How to end a formal telephonic conversation

Unit-III **(06 Contact Hours**

Career Planning & Job-Skill Analysis - ASK: Talking about one's Attitudes, Knowledge, & Skills - SMART goals - Reading & Analysis of Job Advertisements

Unit-IV **(06 Contact Hours**

CV & Resume Writing - Difference between CV & Resume - Writing CV - Writing Resume - Writing Cover Letter

Unit-V **(06 Contact Hours**

Application for Internship - Application for internship in Academic Labs - Application for internship in Industries - Follow up the Application with reminders and requests

Unit-VI **(06 Contact Hours**

Interview Skills - Preparation for the Interview - Frequently asked questions - Dress Codes, Appearance, and Etiquettes. 6.4 Facing the Interview

References:

1. *Business Communication Today*, 12th Edition, Courtland L Bovee & John Thill, Pearson
2. British Council Material on Career Planning & Interviews
3. *Master the Group Discussion & Personal Interview - Complete Discussion on the topics asked by reputed B-schools & IIMs* by Sheetal Desarda, Notion Press
4. *Group Discussion and Interview Skills* by Priyadarshi Patnaik , Cambridge University Press India
5. *The Ultimate Guide to Internships: 100 Steps to Get a Great Internship and Thrive in It* by Eric Woodard
6. Telephone Etiquette by Robert DeGroot

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

CO 1	Get used to a variety of GDs to understand the principles, finer nuances, and intricacies of the art
CO 2	Get exhaustive information on how to prepare for internship and interview

CO 3	Write his/her CV to remain well-prepared for the interviews
CO 4	Take decision on his/her career goals and plans
CO 5	Attain professional speaking skills to enhance his/her employability skills.

Assessment Method:

Course Nature: LABORATORY

Internal Assessment (40 Marks)	**External Assessment (**60 Marks)
Record Writing – 10 Marks	Reading Comprehension – 15 Marks
Attendance – 10 Marks	Writing – 30 Marks
Continuous Assessment (Listening – 10 Marks + Oral Presentations – 10 Marks)	Speaking (Viva-Voce) – 15 Marks

Course Code	Course Name	Course Category	L – T - P	Credits
	Gender sensitization	**MC**	**2-0-0**	**0**

Course Learning Objectives:

1. To develop students' sensibility with regard to issues of gender in contemporary India.
2. To provide a critical perspective on the socialization of men and women.
3. To introduce students to information about some key biological aspects of genders.
4. To expose the students to debates on the politics and economics of work.
5. To help students reflect critically on gender violence.
6. To expose students to more egalitarian interactions between men and women.

Course Content:

Unit-I :

Introduction: Definition of Gender-Basic Gender Concepts and Terminology-Exploring

Attitudes towards Gender-Construction of Gender-Socialization: Making Women, Making Men - Preparing for Womanhood. Growing up Male. First lessons in Caste.

Unit-II:

Two or Many? -Struggles with Discrimination-Gender Roles and Relations-Types of Gender Roles- Gender Roles and Relationships Matrix-Missing Women-Sex Selection and Its Consequences- Declining Sex Ratio. Demographic Consequences-Gender Spectrum: Beyond the Binary

Unit-III:

Division and Valuation of Labour-Housework: The Invisible Labor- "My Mother doesn't Work." "Share the Load."-Work: Its Politics and Economics -Fact and Fiction. Unrecognized and Unaccounted work. -Gender Development Issues-Gender, Governance and Sustainable Development-Gender and Human Rights-Gender and Mainstreaming

Unit-IV:

The Concept of Violence- Types of Gender-based Violence-Gender-based Violence from a Human Rights Perspective-Sexual Harassment: Say No! -Sexual Harassment, not Eveteasing- Coping with Everyday Harassment- Further Reading: "Chupulu".

Domestic Violence: Speaking OutIs Home a Safe Place? -When Women Unite [Film]. Rebuilding Lives. Thinking about Sexual Violence Blaming the Victim-"I Fought for my Life…."

Unit-V:

Gender and Film-Gender and Electronic Media-Gender and Advertisement-Gender and Popular Literature- Gender Development Issues-Gender Issues- Gender Sensitive Language

Unit-VI:

Gender and Popular Literature - Just Relationships: Being Together as Equals Mary Kom and Onler. Love and Acid just do not Mix. Love Letters. Mothers and Fathers. Rosa Parks-The Brave Heart. **Learning resources**

Reference Books:

The Textbook, "Towards a World of Equals: A Bilingual Textbook on Gender" written by A.Suneetha, Uma Bhrugubanda, DuggiralaVasanta, Rama Melkote, Vasudha Nagaraj, Asma Rasheed, Gogu Shyamala, Deepa Sreenivas and Susie Tharu published by Telugu Akademi, Telangana Government in 2015.

Course outcomes:

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

1. Students will have developed a better understanding of important issues related to gender in contemporary India.

2. Students will be sensitized to basic dimensions of the biological, sociological, psychological and legal aspects of gender. This will be achieved through discussion of materials derived from research, facts, everyday life, literature and film.
3. Students will attain a finer grasp of how gender discrimination works in our society and how to counter it.
4. Students will acquire insight into the gendered division of labour and its relation to politics and economics.
5. Men and women students and professionals will be better equipped to work and live together as equals.
6. Students will develop a sense of appreciation of women in all walks of life.
7. Through providing accounts of studies and movements as well as the new laws that provide protection and relief to women, the textbook will empower students to understand and respond to gender violence.

Course Code	Course Name	Course Category	L-T-P	Credits
20MM3201	**Metal Joining and Non Destructive Testing**	**PCC**	**3-1-0**	**4**

Course Learning Objectives:

1. To learn principles of different materials joining processes
2. To study different welding process equipment'sand its operations
3. To study formation of microstructures during welding, brazing and soldering
4. To understand principles of joining of ferrous and non-ferrous alloys
5. To provide a brief knowledge about the basics of NDT and its classification.

Course Content:

Unit-I : **(10 Hrs)**

Scope of metal joining, Techniques of metal joining, Mechanisms for obtaining metallic continuity, Classification of welding processes; Arc Characteristics: Plasma, electron emission and ionization potential, arc temperature, influence of magnetic fieldson arcs, arc blow, metal transfer, effect of polarity, effect of gases, Power Sources: Power source characteristics, static and dynamic characteristics, CC and CV power source designs,current and voltage relationships, solid state power sources.

Unit-II: **(10 Hrs)**

Detailed description about the process equipment, control of parameters, consumable,specifications for electrodes and filler metals and applications related to the following processes: Shielded metal arc welding,gas metal arc welding, flux cored arc welding, gas tungsten arc welding, plasma arc welding, submerged arc welding, studarc welding.

Unit-III: **(10 Hrs)**

Principles, advantages disadvantages and fields ofapplication of the following welding processes:Oxy-fuel gas welding, Electro Slag Welding, Resistance welding, Electron Beam Welding, Laser beam Welding, thermit welding , solid state welding processes – friction welding, friction stir welding, explosive welding, ultrasonic welding, diffusion welding.

Unit-IV: **(10 Hrs)**

Thermal cycles in welding: Heat transfer in weldments, dissipation of welding heat, cooling rates, weld metal coolingcurves, peak temperature, calculating width of heat affected zones, solidification rate and effects of heat input; Development of residual Stresses and distortion; Comparison of welding processes based on these considerations, WELDING DEFECTS: Defects-appearances, their causes and remedies.

Unit-V: **(10 Hrs)** Scope and advantages of NDT, Comparison of NDT with DT. Classification of different NDT techniques. Liquid Penetrant Inspection: principle, applications, advantages and limitations, dyes, developers and cleaners, fluorescent penetrant test. Magnetic Particle Inspection: Principles, applications, magnetization methods, magnetic particles, dry technique and wet technique, demagnetization, advantages and limitations. Magnetic Flux Leakage Testing-principle, instrumentation and applications. ULTRASONIC TESTING: Types of ultrasonic waves, characteristics of ultrasonic waves, attenuation, couplants, probes, EMAT. Inspection methods-pulse echo, transmission and phased array techniques, types of scanning and displays, angle beam inspection of welds, time of flight diffraction (TOFD) technique, LASER ultrasonic testing, calibration: ASTM Test blocks, IIW-reference blocks.

Unit-VI: **(10 Hrs)**

ELECTROMAGNETIC INDUCTION TECHNIQUES: Principle, instrumentation and applications of Eddy current testing and remote field testing. RADIOGRAPHY TESTING: Sources-X-rays and Gamma rays and their characteristics-absorption, scattering. Filters and screens, Imaging modalities-film radiography and digital

radiography (Computed, Direct, Real Time, CT scan). Problems in shadow formation, exposure factors, inverse square law, exposure charts, radiographic equivalence. Penetrameters, safety in radiography.

Learning resources

Text book:

1. Parmer R.S., "Welding Engineering and Technology", 1stEdition, Khanna Publishers, New Delhi, 2008.
2. Robert and Messler, Principles of Welding (Processes, Physics, Chemistry and Metallurgy), Wiley InterscincePublishers, 2008
3. "Non Destructive Evaluation and Quality Control", Metals Handbook, Vol. 17, 9th Ed., ASM, 1989

Reference Books:

1. Lancaster, The Metallurgy of Welding, 6th Edition, William Andrew Publishing, NY, 2007
2. S Kou, Welding Metallurgy, John Wiley, USA, 2003
3. Welding Hand Book Vol. 5; 7th edition, AWS.
4. Baldev Raj, Jayakumar T, Thavasimuthu M, Practical Non-Destructive Testing, 3rd Ed., Narosa, 2009
5. Srivastava, K.C., "Handbook of Magnetic Particle Testing", Oscar Publications, 1998

Course outcomes:

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

1. Identify suitable joining methods for ferrous and non ferrous alloys
2. Explain formation of microstructure and development of mechanical properties during welding, brazing and soldering
3. Analyze different defects formation during joining processes and makes suitable remedies.
4. Recognize the importance of Nondestructive testing in the inpection and quality control.
5. Explain the principles and procedures of nondestructive techniques. **Assessment Method**

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MM3201	Computational Materials Engineering	PCC	3-0-0	3

Course Content:

Unit-I :

Introduction to U buntu and freeware software for simulation

Unit-II:

Tools for the simulation-short introduction to- The C programming language, GNU plot – the plotting freeware, GNU Octave for computations and plotting, Scilab: the scientific computation package, Some miscallaneous freeware

Unit-III:

Dealing with Data- Plotting, fitting, interpolation, Numerical Integration, Numerical Differentiation

Unit-IV:

Structure, thermodynamics and phase transformations- structure and defects, regular solution model, Diffusion and precipitate growth kinetics, spinodal decomposition, ordering.

Unit-V:

Introduction to the concepts in statistical mechanics

Unit-VI:

Molecular Dynamics- Introduction to open-source software LAMMPS, basics of molecular dynamics for atomic systems, simple molecular dynamics code for 2D structures Monte Carlo simulation for atomic systems, simple code for 2D structures

Learning resources

Reference Books:

1. Materials Science and Engineering, V Raghavan,Prentice-Hall India, 2004
2. Advanced Engineering Mathematics,E Kreyzig, Wiley-India,1999
3. Introduction to Methods of Numerical Analysis, S. S. Sastry, EEE edition
4. Computer Oriented Numerical Methods , V Rajaraman, EEE edition
5. Introduction to Computational Materials Science: Fundamentals to Applications, Rechard LeSar, MRC, Cambridge University Press-2013.

Assessment Method

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MM3181	**Metal Joining and Non-Destructive Testing Laboratory**	**PCC**	**0-0-3**	**1.5**

List of Experiments

1. Preparation of a butt joint with mild steel plates using Arc welding process and observe the microstructure of welded joint
2. Welding and visual inspection of defects of mild steel specimens by gas welding
3. Preparation of a butt joint with mild steel strip using Tungsten Inert Gas (TIG) welding process and observe the microstructure of welded joint
4. Preparation of a butt joint with mild steel plate using MIG welding process and observe the microstructure of welded joint
5. Preparation of a butt joint with Aluminum plate using Friction Stir welding process and observe the microstructure of welded joint
6. Study the effect of various parameters of soldering and brazing processes on strength of joint.
7. Dye penetrant inspection.
8. Magnetic Particle inspection.
9. Ultrasonic thickness measurement and flaw detection.
10. X-ray radiography (Film Interpretation).
11. Eddy current testing. **Assessment Method**

Assessment Tool	Experiments	Record	Viva-Voce/ Quiz/MCQ/Lab project	Total
Weightage (%)	25%	5%	10%	40%
End Semester Examination weightage (%)				60%

Course Code	Course Name	Course Category	L-T-P	Credits
20MM3282	**Computational Materials Engineering Laboratory**	**PCC**	**0-0-3**	**1.5**

List of Experiments

Development and execution of illustrative computer programs pertaining to the following topics.

1. Computation of phase diagrams and property diagrams.
2. Finite difference method for heat conduction and solidification.
3. Finite element method for elasto-plastic deformation.
4. Simulated annealing for finding global minimum of a function.
5. Genetic algorithms for steel making processes and optimization.
6. Artificial Neural networks for steel making processes and optimization.
7. First-principles calculation of enthalpies of elements.
8. Monte Carlo simulations.
9.

Assessment Method

Assessment Tool	**Experiments**	**Record**	**Viva-Voce/ Quiz/ MCQ/Lab project**	**Total**
Weightage (%)	25%	5%	10%	40%
End Semester Examination weightage (%)				60%

Course Code	**Course Name**	**Course Category**	**L – T - P**	**Credits**
20EG3283	**English Language Communication Skills Lab-III**	**HSC**	**0-0-3**	**1.5**

Course objectives:

1. To improve interpersonal skills of the students
2. To help the students to write professional letters and reports

3. To practice the etiquettes to be used at workplace
4. To reward hands on experience on managing meetings
5. To imbibe leadership qualities in the students

Course Content

Unit-I **(06 Contact Hours)**

Professional Presentation - Collecting & Reading the materials to be presented - Analyzing the main points - Summarizing & concluding - Developing PPT - Delivery of the Presentation

Unit-II **(06 Contact Hours)**

Report Writing & Writing Professional Emails & Applications – Routine Reports – Investigative Reports - Professional Emails - Formal Letters and Applications

Unit-III **(06 Contact Hours)**

Agenda, Meetings, & Minutes - Setting the agenda for a meeting - Managing a meeting - Keynote address & vote of thanks - Publishing the minutes

Unit-IV **(06 Contact Hours)**

People skills and small talks (2 minutes) - Talking to professional executives - Talking to colleagues - Talking to the boss - Talking to your team - Talking to the media delegates

Unit-V **(06 Contact Hours)**

Corporate Etiquettes - How to introduce & greet - How to raise a question - How to clarify a doubt - How to say "yes" or "no" - Rapport building - Dining & winning - Counseling somebody - How to influence & motivate

Unit-VI **(06 Contact Hours)**

Life Skills - Leadership communication - Interpersonal communication - Stress management - Time Management

References:

1. *Business Communication Today*, 12th Edition, Courtland L Bovee & John Thill, Pearson
2. British Council Material on communication
3. Training in Interpersonal Skills: Tips f: Tips for Managing People at Work by Robbins and Hunsaker
4. Soft Skills for Everyone, with CD Paperback –by Jeff Butterfield
5. Communication for business by Shirley Taylor, Pearson

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

CO 1	The art of professional presentation

CO 2	Write professional reports and letters
CO 3	Conduct a formal meeting
CO 4	Develop people skills and corporate etiquettes
CO 5	Gain the basic knowledge about leadership communication, stress management and time management

Assessment Method:

Course Nature: LABORATORY

Internal Assessment (40 Marks)		**External Assessment (**60 Marks)	
Record Writing	– 10 Marks	Reading Comprehension	– 15 Marks
Attendance	– 10 Marks	Writing	– 30 Marks
Continuous Assessment (Listening – 10 Marks + Oral Presentations – 10 Marks)		Speaking (Viva-Voce)	– 15 Marks

Course Code	Course Name	Course Category	L-T-P	Credits
20BM4101	**Managerial Economics & Financial Analysis**	**HSC**	**3-0-0**	**3**

Course Learning Objectives:

1. To strengthen students managerial skill.
2. To enhance the conceptual clarity in economic concepts.
3. To develop to forecasting capability.
4. It will help to produce multi-disciplinary thought.
5. It will enhance their conceptual and practical/hand on practice in accounting.
6. It will help to implement and understand the uses of ratios.

Course Contents:

Unit I: **(7 hours)**

Introduction to managerial economics, consumer behavior, demand, demand analysis, demand forecasting, supply, supply analysis.

Unit II: **(7 hours)**

Theory of production, production functions, concept of cost, cost analysis, break even analysis.

Unit III: **(7 hours)**

Market structure-monopoly, oligopoly, monopolistic, prefect market; Types of business organizations-sole proprietorship, partnership, private ltd. Companies and public ltd. Companies, formation of company.

Unit IV: **(8 hours)**

Introduction to capital, capital sources, capital budgeting- NPV, IRR, Payback period, profitability index.

Unit V: **(8 hours)**

Introduction to financial accounting, rules of debit-credit, Double-Entry Book Keeping, Journal, Ledger, Trial Balance- Final Accounts (Trading Account, Profit and Loss Account and Balance Sheet with simple adjustments, Preparation of final account and other related accounting statements.

Unit VI: **(8 hours)**

Financial statements, comparative statement analysis, common- size statement analysis, ,ratio analysis, time series (only theories).

Learning resources

Text book:

1. 1. Aryasri, A. R., *Managerial Economics & Financial Analysis*, McGraw Hill, 2014.

Reference Books:

1. Siddiqui., *Managerial Economics & Financial Analysis*, 2e, New Age International Private Limited, 2017.
2. . Pandey, I.M., "*Financial Management*", 11e, Vikas Publishing House, 2015.
3. . Prasanna Chandra., "*Financial Management: Theory and Practice*", 9e, Mc Graw Hill Education, 2015.

Web resources:

1. Managerial Economics and Financial Analysis, Dr. Trupti , IIT Bombay *http://nptel.ac.in/courses/110101005/*

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

CO 1	A student will be able to understand basic economics as well as management concepts.
CO 2	This subject will provide implication facilities of concepts.
CO 3	Students can be able to do primary data collection and classification.
CO 4	Students can also be able to forecast as well as generate trend series by utilizing the available secondary data.
CO 5	They have basic knowledge about accounting and its terminologies.
CO 6	They will be able to prepare and understand accounting tables.

For Theory courses only:

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Professional Elective Courses syllabus

Course Code	Course Name	Course Category	L-T-P	Credits
20MM3203	Electronic and Magnetic Properties of Materials	PEC	3-0-0	3

Course Content:

Unit-I:

Unit-I: Review of electron theory of metals; Electrical and thermal conductivity – Classical approach and quantum mechanical considerations; Resistivity of pure metals and alloys, and ordered alloys; thermoelectric phenomena.

Unit-II:

Semiconductors; Band structures, intrinsic semiconductors, extrinsic semiconductors; Hall effect; Elemental and compound Semiconductors and their application;

Unit-III:

Super conductivity; super conducting materials; Structure and application. Ferromagnetism; Ferromagnetic domains; Hysteresis loops, magnetostriction and magnetoelectricity, origin of Hysteresis due to domain wall movement; soft magnetic alloys.

Unit-IV:

Factors determining the permeability of metals and alloys; Effect of fundamental properties on permeability, Ni-Fe alloys, Fe-Co alloys, high permeability of iron and ferritic iron, Si – Fe alloys and Cu – Ni alloys. Amorphous ferromagnetic alloys and Ferro fluids; Preparation and structure of amorphous ferromagnetic and its application;

Unit-V:

Ferro fluids; Ferri magnetic material; Spiral structure; Theory of ferrimagnetisms; magnetic structures of ferrites; permeability of ferrites; stress-induced anisotropy in ferrites; Applications of soft ferrites.

Unit-VI:

Permanent magnetic materials; Energy product of a permanent magnet material; Behavior of permanent magnets under dynamic or recoil conditions; Alnicos; Fe- Cr-Co alloys. Cu-Ni-Fe and Cu-Ni-Co alloys; Fe-Co-Mo alloys, Pt-Co alloys; $SmCo_5$ magnets; Permagnent, magnets based on the intermetallic compound Sm2 Cal2 Coercivity mechanisms; Applications of permanent magnetic; Temperature dependence of magnetic properties of permanent magnets;

Text book:

1. R.E. Hummel; Electronic Properties of materials.
2. R.A. Macurie; Ferromagnetic Materials structure and properties.

Reference Books:

1. An Introduction to Materials science-H.L.Mancini
2. Magnetic Materials – Fundamentals and Device applications – Nicola Spaldin
3. Fundamentals of Semiconductors - physical and Materials Properties – Peter Y. Yu Manuer Cardona
4. Semi Conductors – Halbleiter .. Ed. Annuelle **For Theory courses only:**

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MM3204	Polymer Product Design	PEC	3-0-0	3

Course Learning Objectives:

1. To impart knowledge of different international standards used in product design.
2. To develop the ability of selecting proper material for plastic products based on the end use.
3. To equip with the knowledge of design calculations and optimization techniques in plastic product design.
4. To provide understanding of finite element analysis in the design of plastic product design.

Course Content:

Unit-I:

Introduction to product design, product design methodology, concurrent engineering, product life cycle, voice of customer, technical specification, concept generation, design for X, FMEA.

Unit-II:
Hrs)

Limits, fits and tolerances – type of fits. Design of ribs and bosses. Design considerations for wall thickness – fillets – sharp corners. Molded threads and their types. Material selection for strength and rigidity – design for stiffness – processing limitations on polymer product design. Mould design for part requirement, stress-strain behavior of polymers, structural design of beams and other structural members. Steps in design, Mohrs circle, BIS standards, theories of failures of biaxial stress system and factor of safety.

Unit-III:

Fatigue loading – type of fatigue loading – S-N curve – simple problems by using fatigue equations – dynamic load response of polymers. Design for cylindrical and spherical pressure vessels by using simple equations. Materials for gears – types – basic terminologies – molded and cut gears – design for strength and durability. Bearings – types of bearings – design consideration – materials – self lubricated plastic materials – p-v rating of bearings.

Unit-IV:

Design of plastic springs – close coiled – Wahl's equation. Couplings – types. Design of seals and O-rings -flat belts and V-belts. Design of inserts – factors to be considered – mould strength – location of inserts in the part – cracking at the inserts. Design for undercuts – cored out sections in molded parts.

Unit-V:

Vibration dampers: Basic vibration damping relations – octave rule for damped systems – under damping – over damping and critical damping, vibration isolation, vibration of single and two rotor systems. Introduction to optimum design – general principles of optimization – problem formulation and their classification.

Unit-VI:

Check for functionality, finite element analysis – introduction – type of analysis –requirement of approximation – weight residual, Ritz and Galerkin method – model building, post processing – simple problems on 2D. Understanding of flow analysis, optimum gate locations, pressure drops across runner, fill analysis, shrinkage and warpage.

Text book:

1. Hand book of Plastics Product Design Hand Book,- Miller.E, Marcel Dekker.
2. Fibre Plastic Part Design for Injection Moulding- An Introduction, - Robert A. Malloy, Carl Hanser **Reference Books:**

1. Plastics Extrusion Technology" - R.J.Crawford, Pergamon, Hanser.
2. Injection Mold Design Engineering", Hanser, 2007
3. Engineering Design with Polymers and Composites - James.C.Gerdeen

Course outcomes: The outcomes at the end of this course are as follows:

1. The student will able to select the plastic materials based on end use applications of products.
2. The student able to design plastic products for different working conditions with geometrical and financial considerations.
3. The students will be able to plan the dimensions of plastic gears, bearings and springs.
4. The students will be able to validate a plastic product design by finite element methods

For Theory courses only:

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	**Course Name**	**Course Category**	**L-T-P**	**Credits**
20MM3205	**Soft Materials**	**PEC**	**3-0-0**	**3**

Course Learning Objectives:

1. To underpin the significance of soft materials in controlling complex living systems
2. To make students aware of the various classes of soft materials
3. To signify the role of self-assembly and the formation of varied architecture
4. To introduce the various instrumental characterization techniques for soft materials

Course Content:

Unit-I:

The concept and development of soft materials, Nature of supramolecular interactions for the soft materials; Noncovalent interactions, ion-ion interactions, Ion-dipole interactions, Dipoledipole interactions, π-π stacking, Cation- π interactions,

Unit-II:

Solvophobic interactions; van der Waals interactions, Hydrogen bonding, Multiple hydrogen bonding motifs, Jorgensen model for H-bonding; Photoresponsive molecules and selfassembly, Micelles, Vesicles, Toroids, Colloids, Rods

Unit-III:

The concept of supramolecular self-assemblyone, two and three dimensional self-assemblies, Phthalic acid based self-assemblies, Cyanuric acidmelamine assemblies, Rosette motifs, Hierarchical self-organization

Unit-IV:

Perylenebisamide-melamine assemblies, Oligo(p-phenylenevinylene and pphenyleneethynylene) self-assemblies, Supramolecular polymers resulting from quadruple Hbonding modules, Molecular capsules, Self-assembled dendrimers, Self-assembled nanotubes; Molecular motors; Liquid crystals.

Unit-V:

Different class of gels- low molecular weight organo gels, hydrogels, basics, classifications, Structure and theory of formation, Swelling, Physical hydrogels, Ionic and hydrogen bonding in gels.

Unit-VI:

Polyelectrolyte gels, Coacervatives, Covalently bonded hydrogels, Applications of hydrogels Behaviour of soft materials under zero gravity.

Reference Books:

1. J. -M. Lehn, Supramolecular Chemistry: Concepts and Perspectives, Wiley VCH Verlag, 1995.
2. J. Steed, J. L. Atwood, Supramolecular Chemistry, 2nd ed., John Wiley, 2009.
3. J. Steed, J.L. Atwood, Organic Nanostructures, 2 nd ed., Wiley VCH Publishers, 2008. 4. V. V. Tsukruk, S. Singamaneni, Scanning Probe Microscopy of Soft Matter: Fundamentals and Practices, Wiley VCH Publishers, 2011.
5. N. Takashi, Supramolecular Soft Matter, 1st ed., John Wiley & Sons, 2011.
6. V.K. Pillai, M. Parthasarathy, Functional Materials: A Chemist's Perspective, Orient BlackSwan, Universities Press- IIM Series, 2013.
7. S. K. Tripathy, Jayant Kumar, H.S. Nalwa, Handbook of Polyelectrolytes and Their Applications,

8. American Scientific Publishers, 2003.
9. B. Rolando, Hydrogels Biological Properties and Applications, 2nd ed., Springer, 2009.

Course outcomes: The outcomes at the end of this course are as follows:

1. Students will develop a fundamental understanding of the various classes of soft materials that are relevant for technological applications in different sectors including materials industry and consumer products.
2. Students will appreciate the role of molecular units in the design of soft materials and understand the process of self-assembly.
3. Students will get exposed to synthesis, processing and characterization of soft materials during the laboratory sessions planned along with the course.

For Theory courses only:

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MM3206	**Advanced Materials and Processes**	**PEC**	**3-0-0**	**3**

Course objectives:
The objective of this course is to

1. Understand different structures of materials and symmetry of them.
2. Gain knowledge about processing and applications of advanced materials like nanocrystalline materials, amorphous materials, quasi crystals, nano-quasi crystals.

3. Discuss about the processing methods and applications of shape memory alloys, advanced Al alloys, Ti-alloys and super alloys.
4. Acquire the knowledge about strengthening mechanisms.

Course Content:

Unit – 1 :

Platonic solids, Quasicrystals, Symmetry of crystal structure (CTORHMT), Nano-crystalline Materials, Grain size variation from micron to nano size by several methods, Effect of grain boundaries, Phase solubility in nano crystalline state, Techniques to get nano crystalline state (Synthesis).

Unit – 2 : Introduction, Zr-Ni system, Peak broadening effect, Solid state amoriphization, Amorphization criteria, Inherent grain stability, Factors affecting amorphization, Liquid state amorphization, De-siliconization, De-phosphorization, De-sulphurization.

Unit – 3 :

Introduction, Classification of quasicrystals, Effect of oxygen in quasicrystalline phase formation, Nano quasicrystals.

Unit – 4 :

Rapid solidification, Mechanical alloying, Emulsification droplet techniques, Advantages of extension of solid solubility. Ti-alloys, Shape memory alloys, Psuedo elasticity.

Unit – 5 :

Introduction, Al-Si alloys, Al-Li alloys, Effect of the shape of precipitate, Nano composites of Al based alloys, Al-Ti alloy, Al-Ni alloys, Glass forming ability of Al-alloys.

Unit – 6 :

Strengthening mechanisms in pure metals, Effect of under cooling, strengthening mechanism in alloys, Ni-based, Fe-based & Co-based super alloys, Introduction to MMCs, In-situ composites, Advantages of In-situ processing and examples.

Learning resources

1. Video lectures by Dr.B.S.Murthy at https://www.youtube.com/watch?v=v1qwttBOdA&list=PL716BC63A7418B310.

Course outcomes:

On successful completion of the course, student will be able to

1. Differentiate between different types of advanced materials based on their structures.
2. Identify specific application of nano-crystalline materials, amorphous materials, quasi crystals, nano-quasi crystals.

3. Given and application students will be able to identify the suitable material for that application.
4. Understand the processing methods and applications of shape memory alloys, advanced Al alloys, Ti-alloys and super alloys.

Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	**Course Name**	**Course Category**	**L-T-P**	**Credits**
20MM3207	**Powder Metallurgy**	**PEC**	**3-0-0**	**3**

Course Objectives:

1. To understand the basic principles of Powder metallurgy
2. To Understand the behaviour of sinter ability nature of materials under different environment
3. To Understand the processing of mechanical alloying through it.

UNIT – I:

Historical background, steps in powder metallurgy, advantages of powder metallurgy process, advantages of powder metallurgy processing over conventional material processing, applications of powder metallurgy, limitations of powder metallurgy, recent trends; Powder production methods: Mechanical – milling, machining, other impaction techniques, mechanical alloying, Chemical –reduction, thermal decomposition, hydride-dehydride process, Physical methods – electrolytic deposition, gas atomization, water atomization, centrifugal atomization, other atomization approaches, atomization limitations.

UNIT – II:

Powder treatments – cleaning of powders, grinding, powder classification and screening, blending and mixing; coating of metal powders; Metal powder characteristics: sampling, metal powder characterization – chemical composition analysis, particle shape analysis, particle size, measurement techniques – microscopy, screening, sedimentation, light scattering, light blocking, x-ray techniques; microstructural features; packing and flow characteristics of powders – angle of repose, flow rate; density – apparent density, tap density; porosity; compressibility of metal powder; strength properties.

UNIT – III:

Powder pressing – powder shaping and compaction, binders; powder compaction methods – pressure less compaction techniques, pressure compaction techniques; classification of powder metallurgy parts; cold isostatic compaction – process, types, advantages, applications;.

UNIT – IV:

Powder rolling – steps involved, influence of powder characteristics on powder rolling, advantages, disadvantages, application; miscellaneous compaction techniques – continuous compaction, explosive compaction; High temperature compaction: principles of pressure sintering – uniaxial hot pressing, hot extrusion, spark sintering, hot isostatic pressing, injection moulding.

Unit-V

Types of sintering – solid state sintering, liquid phase sintering, activated sintering, reaction sintering, rate controlled sintering, microwave sintering, self-propagating high temperature synthesis, gas plasma sintering, spark plasma sintering; sintering theory – thermodynamics of solid state sintering process, stages in solid state sintering, driving force for sintering, sintering mechanisms; variables – process variables, material variables; effects of sintering – dimensional changes, microstructural changes;

UNIT – VI

Sintering atmospheres – need for sintering atmosphere, functions of a sintering atmosphere, hydrogen, reformed hydrocarbon gases, nitrogen based mixtures, dissociated ammonia, inert gases, vacuum. **Post sintering operations**: introduction, sizing, coining, repressing, re-sintering, impregnation, Infiltration, heat treatment, steam treatment, machining, joining, plating, and other coatings. Powder metallurgy product: Porous Bearings, Porous Filters, Sintered Carbides, cermets.

Reference &Text Books:

1. Powder metallurgy science – **R M German**
2. Powder metallurgy science,technology & applications – **PC Angelo & RSubramanian**
3. Powder metallurgy- Science, Technology and Materials by **Anish Upadhyaya and G. S. Upadhyaya**

Video Reference: Manufacturing Processes-1: Source: NPTEL Link:
http://nptel.ac.in/courses/112107145/

COURSE OUTCOMES:

1. Learners will be able to understand basic concept of powder metallurgy
2. Learners will be able to understand mechanism of sintering
3. Will be able to design the materials with higher strength and unique properties in industrial application.

Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MM3208	Secondary Steel Making	PEC	3-0-0	3

Course Learning Objectives:

1. This course revises metallurgical thermodynamic concepts
2. Introduces ladle metallurgy steelmaking operations
3. Explains vacuum degassing techniques
4. Describe the methods for control of quality in steel production &Emerging trends in continuous slab castings.
5. Evaluation of various casting procedures towards steel solidification process.

Course Content:

Unit - 1

Introduction: Metallurgical Thermodynamics – Chemical Equilibrium - Activity and Equilibrium Constant -ΔG0 for Oxides - Activity Composition Relationships - Concentrated Solutions – DiluteSolutions - Chemical Potential and Equilibrium.Fluid Dynamics - Inference of Fluid Flow in steelmaking - Force Balance Expressions and MomentumConservation Equations – Boundary Conditions - Laminar and Turbulent Flows - Calculation of Turbulent Flowsin Steelmaking.Heat Transfer - Mechanism of Heat Transfer - Heat Conduction - Convective Heat Transfer - Radiation.

Unit - 2

Mass Transfer and Metallurgical Kinetics - Mechanism of Mass Transfer – Molecular Diffusion – Convective Mass Transfer – Chemical Reaction Kinetics.

Slag Carry-over: Impact on Ladle Metallurgy, Deoxidation - Techniques of Deoxidizer Addition - Physical and Chemical Interaction between Solid Additions and Steel Melt - Types of Deoxidation - De oxidation Kinetics and Products.Ladle Metallurgy Steelmaking Operations

- Construction of Steelmaking ladles; Ladle Refractory, Preheating and Recycling

Unit - 3

The Method of Inert Gas Stirring in Ladles - Temperature and Composition Control in Ladles.

The Ladle Furnace - Injection Metallurgy -Miscellaneous Issues in Ladle Metallurgy. Vacuum Degassing - Principles – Degassing Techniques - Stream Degassing – Tank Degassing – CirculationDegassing - Thermodynamics and Kinetics of Hydrogen and Nitrogen Removal under Vacuum – Water Capacity of Ladle Slags.

Unit-4 Clean steel -

Cleanliness Assessment - Inclusions and Mechanical Properties – Sources of Inclusion in

steel Types of Inclusions - Properties of Inclusions - Inclusion Engineering.Tundish Metallurgy - Tundish Design and Operations - Temperature and Cleanliness Control in Tundish Sequence Casting and Grade Transition - Residual Metal loss in Ladles and Tundish.

Unit-5 Fundamental Aspects of Solidification, Casting Processes - Ingot Casting – Continuous Casting – Processdescription – Continuous Casting Products and Casting Defects.

Unit - 6

Emerging Trends in Continuous Slab Casting –EMstirring and EM braking - Gas Injection in
Mold - High Speed Slab Casting - Thin Slab casting Strip Casting. FinalFinishing Operations
- Surface Treatment - Heat Treatment - Shaping and Secondary Product Manufacturing(Including Deformation Processing).

Learning Resources

Text Books:

1. Ghosh, A. and Chatterjee, A., Principles and Practices in Iron and Steel making, Prentice Hall of India.
2. Ghosh, A., Secondary Steelmaking, CRC Press.

Course outcomes:

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

1. Describe the physical and chemical processes that take place during Secondary steelmaking.
2. Analyse the effect of change in process parameters in steelmaking processes
3. Describe the methods for control of quality in steel production
4. Solve numerical problems involving reaction kinetics and composition control

Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MM4101	Foundations of Computational Materials Modelling	PEC	3-0-0	3

Course Learning Objectives:

1. To provide necessary foundations to build computational samples of crystals
2. To introduce statistical mechanics and its connection to Molecular dynamics
3. To provide enough ground in Molecular dynamics using LAMMPS

Course Content:

Unit-I

Introduction to the course, Some applications of MD simulations, Introduction to Bravais lattices and constructing simple crystals with MATLAB, Introduction to symmetry, Symmetry Elements, Plane groups and their Hermann-Maugin (HM) symbols, Glide reflection; Examples of writing point group symbols; Wyckoff positions, Generating 2D crystal with MATLAB using Bilbao crystallography website

Unit-II

Symmetry of space groups, Hernann maugin symbols of space groups, Translational symmetry operators, The Space groups, Generation of crystals, Generation of monoclinic lattice

Unit-III

Introduction to Statistical Mechanics, Statistical mechanics- Microcanonical Ensemble; Entropy and the Second Law; Temperature; Two-State Spin System; First Law of Thermodynamics; Canonical Ensemble; Energy Fluctuations; Chemical Potential; Grand Canonical Ensemble

Unit-IV

Introduction to phase space, Introduction to phase average and time average, Canonical ensemble; Partition function

Unit-V

Basic introduction to Molecular Dynamics, Input script for LAMMPS,
LAMMPS exercises 1, LAMMPS exercises 2,

Unit-VI

LAMMPS exercises 3, LAMMPS exercises 4, LAMMPS exercises 5

Learning Resources

https://nptel.ac.in/courses/112/106/112106289/#

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Course outcomes:

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

1. Understand fundamentals of computational materials modelling
2. Use molecular simulation of solids

Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MM4102	Nanomaterials – Synthesis and applications	PEC	3-0-0	3

Course Objectives:

1. To understand the surface chemistry of nanomaterials
2. Classification of nanomaterials such as 0D, 1D, and 2D materials
3. To gain knowledge of the various process techniques to synthesis Nanostructured materials.
4. To understand the factors controlling growth of the nanomaterials
5. To know the various applications of nanomaterials / nanotechnology

Unit I:

Introduction to nanomaterials and nanostructures including both inorganic and organic materials, Top & Bottom up approaches, Challenges in Nanotechnology,Physical Chemistry of solid surfaces- Surface energy, Electrostatic-Van der Waals attraction potential, Interactions between two particles (DLVO theory), and Steric stabilization-Interactions between polymer layers, Mixed steric and electric interactions.

Unit II:

Homogeneous nucleation and subsequent growth, synthesis of oxide nanoparticles, Synthesis of metallic and semiconductor nanoparticles- Influences of reduction reagents,Influences of polymerstabilizer,Solgel, Hydrolysis, vapor phase reactions, **Solid** state phase segregation.

Unit III:

Fundamentals of heterogeneous nucleation,Heterogeneous nucleation and subsequent growth,Nanoparticles through Heterogeneous Nucleation,kinetically confined synthesis of nanoparticles –Aerosol synthesis, Spray paralysis, Template Based synthesis, and Growth termination processes.

Unit IV:

Spontaneous growth, Evaporation- Condensation growth, Dissolution- Condensation growth,
Vapor (or solution) – liquid – solid (VLS or SLS) growth,Template-Based Synthesis-Electrochemical deposition, Electrophoretic deposition,Template filling, Electrospinning, Lithography.

Unit V:

Fundamentals of Film Growth, Physical Vapor Deposition (PVD)-Evaporation, sputtering, the comparison between evaporation and sputtering, Chemical Vapor deposition (CVD) - Typical chemical reactions, Reaction kinetics, CVD methods,Atomic Layer Deposition (ALD), Super lattices, self assembly, Electrochemical deposition, Solgel films.

Unit VI:

Molecular Electronics and Nanoelectronics, Nanobots, Biological Applications – Quantum Devices – Nanomechanics - Photonics- Nano structures as single electron transistor – principle and design, Photoelectrochemical Cells.

TEXT BOOKS

1. Guozhong Cao, "Nanostructures and Nanomaterials, synthesis, properties and applications", Imperial College Press, 2004.

2. Yury Gogotsi, "Nanomaterials – Handbook", CRC Press, Taylor & Francis group, 2006.

Course Outcome:

1. Introduces the fundamental principles needed to understand the behavior of materials at the nanometer length scale
2. Provides a comprehensive overview of nanomaterials in terms of the synthesis, characterization, properties, and applications.
3. Gives the fundamental scientific principles for the different synthesis techniques, assembly of nanostructured materials, and new physical and chemical properties at the nanoscale.
4. Get to know the Existing and emerging applications.

Assessment Method

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total

Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MM4103	**Introduction to Crystallographic texture and related phenomenon**	**PEC**	**3-0-0**	**3**

Course Learning Objectives:

1. To provide a brief knowledge on texture and its measurements.
2. To develop the texture by different techniques and deformation microstructure.
3. To understand the modelling techniques and the annealing phenomenon.
4. To introduce the texture development during coatings and thin film deposition.
5. To understand influence of texture on mechanical, chemical and physical properties.
6. To obtain knowledge on texture and formability by case studies

Course Content:

Unit -1:

Concepts of texture in materials, their representation by pole figure and orientation distribution functions; Texture measurement by different techniques: X-ray diffraction, neutron diffraction, synchrotron X-rays, ultrasonic waves.

Unit-II:

Origin and development of textures during materials processing stages: solidification, deformation, annealing, phase transformation. Deformation microstructure and texture in FCC, BCC and HCP metals and alloys.

Unit-III:

Modelling of deformation texture, Sachs, Taylor and Self consistent models for polycrystal deformation and texture evolution. Annealing phenomenon: Recovery, recrystallization and grain growth, texture evolution during annealing.

Unit-IV:

Solidification and transformation texture.Texture development during coatings and thin film deposition.

Unit-V:

Influence of texture on mechanical, chemical and physical properties: Yield strength, ductility, fatigue, corrosion, stress corrosion cracking, magnetic and dielectric properties **Unit-VI:**

Texture and formability. Case studies: Texture control in aluminium industry, automotive grade and electrical steels, magnetic and electronic materials.

Learning resources

Text Books:

1. Introduction to Texture Analysis: Macrotexture, Microtexture and orientation mapping, Gordon and Breach Science Publishers, V. Randle and O. Engler
2. Recrystallization and Related Annealing Phenomenon, Pergamon Press, F.J. Humphreys and M. Hatherly.

Reference Books:

1. M. Hatherly and W.B. Hutchinson, An Introduction to Textures in Metals (Monograph No. 5), The Institute of Metals, London.
2. V. Randle and O. Engler, Introduction to Texture Analysis: Macrotexture, Microtexture and orientation mapping, Gordon and Breach Science Publishers.
3. F.J. Humphreys and M. Hatherly, Recrystallisation and Related Phenomenon, Pergamon Press Texture and Anisotropy, U.F. Cocks, C.N. Tome and H.-R. Wenk, Cambridge University Press **Course outcomes:**

On successful completion of the course, student will be able to do

1. Discuss on texture and its measurements.
2. Determine the texture by different techniques and deformation microstructure.
3. Perform the modelling techniques
4. Develop the texture during coatings and thin film deposition.
5. Recognize the different influences of texture on mechanical, chemical and physical properties. Explain the texture and how it influences formability.

Assessment Method

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MM4104	**Surface Science and Engineering**	**PEC**	**3-0-0**	**3**

Course Learning Objectives:

1. The objective of this course is to equip the student with fundamental knowledge on the various surface engineering techniques and characterization of modified zone.
2. Introduces the basic concepts of surface engineering
3. Explains the concepts like classification and basic principle, advantages & disadvantages of different techniques on various applications
4. Explains the evaluation of coating performance by different testing methods.

Course Content:

UNIT 1

Introduction to tribology, surface degradation, wear and corrosion, types of wear, adhesive, abrasive, oxidative, corrosive, erosive and fretting wear, roles of friction and lubrication-, expressions for corrosion rate. emf and galvanic series - merits and demerits -Pourbaix diagram for iron, magnesium and aluminium.

UNIT 2

Forms of corrosion - Uniform, pitting, intergranular, stress corrosion. corrosion fatigue. dezincification. erosion corrosion, crevice corrosion - Cause and

remedial measures - Pilling Bedworth ratio - High temperature oxidation- Hydrogen embrittlement- Remedial Measures.

UNIT 3

Exchange current density, polarization - concentration, activation and resistance, Tafel quation; passivity, electrochemical behaviour of active/passive metals, Flade potential, theories of passivity, Effect of oxidising agents

UNIT 4

Corrosion in fossil fuel power plants, Automotive industry, Chemical processing industries, corrosion in petroleum production operations and refining, Corrosion of pipelines.

UNIT 5

Purpose of corrosion testing - Classification - Susceptibility tests for intergranular corrosion- Stress corrosion test. Salt spray test humidity and porosity tests, accelerated weathering tests. ASTM standards for corrosion testing and tests for assessment of wear

UNIT 6

Organic, Inorganic and Metallic coatings, Electroless plating and Anodising - Cathodic protection, corrosion inhibitors - principles and practice - inhibitors for acidic neutral and other media. Special surfacing processes - CVD and PVD processes **Learning resources**

Reference Books:

1. ASM Metals Handbook. Vol.5. “Surface Engineering”. ASM Metals Park. Ohio. USA. 1994.
2. Kenneth G Budinski. “Surface Engineering for Wear Resistance”. Prentice Hall Inc..Engelwood Cliff., New Jersey. USA 1988
3. Fontana and Greene. “Corrosion Engineering”. McGraw Hill Book Co. New York. USA,1986.
4. Raj Narayan. “An Introduction to Metallic Corrosion and its prevention”, Oxford & 1BH, New Delhi,1983.
5. Denny A. Jones, ”Principles and Prevention of Corrosion” 2nd Edition, Prentice Hall of India,1996.
6. Uhlig. H.H. “Corrosion and Corrosion Control”. John Wiley & Sons. New York. USA. 1985.
7. ASM Metals Handbook. Vol.l3,”Corrosion”. ASM Metals Park. Ohio. USA. 1994

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

1. Understanding of basic concepts of surface engineering
2. Ability to get an idea on various techniques of surface engineering and their advantages and disadvantages
3. Understanding of coating performance and characterization of modified zone

Assessment Method

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MM4105	**Light Metals and Alloys**	**PEC**	**3-0-0**	**3**

Course Objectives:

1. Provide the knowledge about importance and classification of Light metals and alloys.
2. Understanding the melting methodologies of light metal alloys.
3. Understanding production and processing techniques & applications of Super alloys & Ti-alloys.
4. Acquire knowledge about the applications of Light metals and alloys.

Course Content:

Unit 1:

Classification of light metal alloys, their properties, importance of strength / wt ratio in engineering applications. Detailed engineering applications, Indian / International specifications.

Unit 2:

Melting methodology of light metal alloys used of melting / refining flows. Casting characteristics of light metal alloys (Ag, Mg, Te alloys). Light metal alloys foundry practices, master alloy used in melting.

Unit 3:

Physical metallurgy of light metals alloys, rolling, sheet metal working, extrusion etc.

Unit 4:

Special Alloys: Duralumin, Al-Li, Mg-Li alloys – production and processing techniques & applications.

Unit 5:

Titanium alloys: Alloying elements and their effects, types of alloys, their processing, heat treatment, properties and selection.

Unit 6:

Strategic applications of light metal alloys, air craft industries. Functional considerations. Defects analysis in cast and rolled products. Failure analysis of light metal alloys components.

Learning resources

Text &Reference Books:

1. Non-ferrous Physical Metallurgy – R.J. Raudebaugh
2. Light Alloys – I..J.Polmear
3. Light Metals – C.M. Bickett.
4. Heat Treatment Processing & Properties of Non Ferrous Alloys – C. R. Brooks, ASM

Course Outcomes:

By the end of this course students will be able to

1. Understand the importance and classification of Light metals and alloys.
2. Understand the melting methodologies, production and processing techniques &Super alloys & Ti-alloys.
3. Identify the applications of Light metals and alloys.

Assessment Method

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MM4106	**Melt Treatment in Casting**	**PCC**	**3-0-0**	**3**

Course Learning Objectives:

1. To learn thermodynamics and kinetics of solifications
2. To familiarize with different melting furnace
3. To understand melting treatment of cast iron
4. To understand melting treatment of steel
5. To familiarize with non-ferrous casting production
6. To understand casting defects

Course Content:

Unit-I :

Solidification of Metals and Alloys: Nucleation, Growth, Role of alloy constitution, Thermal conditions and inherent nucleation and growth conditions in the liquid melt, Time of solidification , concept of directionality in solidification Significance and practical control of cast structure. Principles of Gating and Risering: Feeding characteristics of alloys, Types of Gates and Risers, gating ratio.

Unit-II:

Melting furnaces: Classification of furnaces, Gas fired pit furnace, Resistance furnace, Coreless induction furnace, electric arc furnace, constructional features & working principle of cupola furnace, charge calculation,

Unit-III:

CAST IRONS: Graphitization. Types and sizes of graphite for Grey Cast Iron and S.G.Iron. Effect of normal elements and alloying elements in cast Irons. Compositional aspects production melting and properties of austenitic cast irons, high silicon cast irons, high chrome cast Irons, Ni-Hard cast irons. Grey cast iron, S.G.Iron, Austempered S.G.Iron. C.G.Iron ad Malleable cast iron, composition control for cast irons simple problems in composition control.

Unit-IV:

STEELS: Effect of normal elements and alloying elements in steels. Compositional aspects and properties of alloy steels. melting procedure and composition control for carbon steels, low alloy steels and stainless steels. Simple problems in composition control, slag-metal reactions-desulphurization-dephosphorisation, modification and grain refinement of steels.

Unit-V:

NON-FERROUS CAST ALLOYS: Specifications, composition, properties and phase diagrams of Copper, Aluminium, Magnesium, zinc and Nickel base alloys, melting Procedure and composition control for Al alloys, Mg alloys, Nickel alloys, Zinc alloys and copper alloys, modification and grain refinement of Al alloys, problems in composition control

Unit-VI:

GASES IN METALS: Various degassing techniques for metals and alloys. FLUIDITY: Definition, factors affecting and measurement of fluidity. RESIDUAL STRESSES: Origin, effects and stress relieving operations. DEFECTS IN CASTINGS: Identification, their causes and remedies. fish bone diagram, FMEA and WHY analysis.

Learning resources

Text book:

1. Peter Beelay, "Foundry Technology", Butterworth-Heinemann, 2001.
2. Ramana Rao T.V. "Metal Casting Principles and Practice", New Age International (P) Limited, 2003.
3. Jain.P.L. "Principles of Foundry Technology" Tata McGraw- Hill Publishing Co., Ltd, 1995.

Reference Books:

1. Flinn, R.A. "Fundamentals of Metal Casting", Addison – Wesley, 1963.
2. Srinivasan, N. K. "Foundry Technology" Khanna Publications, 2001.
3. Heine, R. W. Loper, C.R. and Rosenthal, P.C. "Principles of Metal Casting" Tata McGraw Hill Publishers, 2003.
4. A. K Chakrabarti, "Casting Technology and Cast Alloys", PHI, 2008
5. K C John, "Metal Casting & Joining" PHI, 2015
6. P. C. Mukherjee, "Fundamentals of Metal casting Technology", Oxford IBH, 1980.

Course outcomes:

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

1. Explain solidification of metals and alloys
2. Choose correct melting furnace and melting practice for different casting metals and alloys.
3. Analyze the irregularities and cause of defects in castings and apply the remedial measures for immediate rectification **Assessment Method**

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MM4107	**Composite Materials**	**PEC**	**3-0-0**	**3**

Course objectives:

1. Introduces the composite materials and their classificatio
2. Acquire knowledge about Characterization of Composites
3. Explains the fabrication, properties and applications of MMC& PMC
4. Explains the fabrication, properties and applications of CMC& CCC

5. Explains fracture mechanics and fracture toughness in composites

Course Content:

UNIT 1

Introduction to Composites, Matrices, Reinforcements, Classifications, Applications, Advantages, Fundamental concept of reinforcement, review of current developments; design fabrication and economic considerations;

UNIT 2

Basic mechanics of reinforcement, Stiffness of parallel arrays of fibres in a matrix. Discontinuous and particulate reinforcement. Fibres and resin materials. Rule of Mixtures, Critical Fiber Length, Short and Continuous Fibers, Fiber Orientation; Matrix and Reinforcement Materials, Polymeric Matrices, Metallic Matrices, Ceramic Matrices, Particulates, Flakes, Whiskers, Fibers: C, B, Glass, Aramid, Al2O3, SiC, Nature and manufacture of glass, carbon and aramid fibres.

UNIT 3

Review of the principal thermosetting and thermoplastic polymer matrix systems for composites. ; Polymer Matrix Composites (PMCs), Metal Matrix Composites (MMCs), Ceramic Matrix Composites (CMCs), CFRP & Carbon/Carbon Composites (CCCs);
Types, Manufacturing, Processing methods, Interfaces, Properties, Applications,

Toughening Mechanisms, Fiber Forms, Prepregs, Molding Compounds-Processes, LayUps, Filament Winding, Pultrusion, Recycling.

UNIT 4

Matrix –Reinforcement Interface, Wettability, Interactions at Interface, Interfacial Bonding Types, Interfacial Strength Tests, The role of the interface. The nature of fiber surfaces, wetting and adhesion

UNIT 5

Strength, Stiffness, Fracture, Toughness and toughening mechanisms of composites Strengths of unidirectional composites. Multiple fracture in laminates. Macroscopic fracture and energy dissipating processes. Application of fracture mechanics to composite materials.

UNIT 6

Fracture Mechanics and Fracture Toughness in Composites, Linear Elastic fracture mechanics, Toughness, Fiber matrix debonding, Fiber Pullout Buckling and PostBuckling; Failure criteria, Fatigue and Creep in composites, Environmental effects in Composites, Green composites; Synthesis and Properties of Nanocomposites.

Learning resources

Reference Books:

1. Chawla, Composite Materials: Science and Engineering, Springer, 2nd Ed. 1998.
2. Matthews & Rawlings, Composite Materials: Engineering and Science, Chapman & Hall, 1994.
3. Hull, An Introduction to Composite Materials, Cambridge, 2nd Edt. 1997.Bhat, S.V., Biomaterials, 2nd edition, Narosa Publishing, 2006

Course outcomes :

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

1. Understand the classification of Composite materials
2. Explain the characterisation of Composite materials
3. Describe the fabrication methods of all the four types of composite materials
4. Expalin the properties of all the four types of composite materials

Explain the applications of all the four types of composite materials.

Assessment Method

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MM4108	**Finite element method in materials engineering**	**PEC**	**3-0-0**	**3**

Course Learning Objectives:

1. To learn Basic Steps in FEM and Variational FEM.
2. To understand about the Alternate formulation in FEM.
3. To learn about Variational Functional methods.
4. To obtain the applications by using FEM and observe the problems faced in it.

Course Content:

Unit -1:

Derivation of Elemental Equations, Assembly, Imposition of Boundary Conditions, Solution of the Equations. 1 -D Elements, Basis Functions and Shape Functions, Convergence Criteria, h and p Approximations. Natural Coordinates, Numerical Integration, Gauss Elimination based Solvers. Computer implementation: Pre-processor, Processor, Post-processor.

Unit-II:

Weighted Residual Method, Galerkin Method; Problems with C1 Continuity: Beam Bending, Connectivity and Assembly of C1 Continuity Elements.

Unit-III:

2-D Elements (Triangles and Quadrilaterals) and Shape Functions. Natural Coordinates, Numerical Integration, Elemental Equations, .Connectivity and Assembly, Imposition of Boundary Conditions. Axisymmetric (Heat Conduction) Problem, Plane Strain and Plane Stress Solid Mechanics Problems.

Unit-IV:

Elements with C1 Continuity. Free Vibration Problems, Formulation of Eigen Value Problem, FEM Formulation.

Unit-V:

Time-dependent Problems, Combination of Galerkin FEM and FDM (Finite Difference Method), Convergence and Stability of FD Scheme.

Unit-VI :

Problems with material non-linearity, Direct solution technique

Learning Resources

Reference Books:

1. Material Science for Engineers – Schakleford.

2. Material Science for Engineers – Vanvlack.

Course outcomes: By the end of this course students will be able to

1. Explain the steps involved in FEM and 1-D elements.
2. Determine the Alternate formulation in FEM.
3. Analyze the Variational Functional methods, 2-D elements and shape functions.
4. Perform the FEM efficiently and applications rectify the problems faced.

Assessment Method

Assessment Tool	**Weekly tests**	**Monthly tests**	**End Semester Test**	**Total**
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MM4109	Ceramic coatings	PEC	3-0-0	3

Course Objectives:

1. The course is aimed to enable the students to have a complete knowledge about the advanced ceramic coating technology processes, properties and applications.
2. Students will learn the fundamental understanding of the ceramic coating
3. Will study the different types of coating technologies
4. Will study the testing of coatings
5. Will study the properties and applications **Course Structure:**

UNIT 1 :

Introduction, classification, Glaze formulation – Segar formula, preparation - raw materials, milling, application, firing, glaze defects.

UNIT 2 :

Definition of thin film and coatings, preparation of substrate- Role of substrate- substrate selection-nucleation and thin film growth- residual stress, thickness measurements.

UNIT 3 :

PVD - basic evaporation process - evaporation techniques - sputtering – ion plating- CVD process-CVD reactor- CVD kinetics- product and process route.

UNIT 4 :

Plasma spray- pack coating- slurry coating- sol gel coating- hot dip coating- electrophoresis- electro chemical coating- corrosion resistant coating and other coatings.

UNIT 5 :

XRD – glancing incidence, x-ray diffraction- electron microscopy techniques- auger electron spectroscopy, secondary ion mass spectroscopy, photoelectron spectroscopy.

UNIT 6 :

Thermal, mechanical. Optical and chemical properties- hardness- wear and erosion resistance- high temperature properties- applications- defects and remedies

Learning resources

TEXT BOOKS

1. Hocking M.G.Vasantasree V Sidky PS, Metallic and Ceramic coatings, Longman, 1989.

2. Boriosenko Al, HighTemperature Protective Coatings,American Publishing Co., New Delhi, 1986.

REFERENCES

1. Lisa C Klien (Ed),Sol Gel Technique for Thin Films, Fibres, Performs, Electronis and Speciality Shapes, Noyes publications, New Jersy, 1988.

2. Orlando Auciello and Rainer Waser, Science and Technology of Electro ceramic Thin film, NATO ASI series- Kluwer Academic publishers, 1995.

Course Outcomes :

On completion of the course the students are expected to

1. Have studied the classification and raw materials used for the special coatings.
2. Have learnt in detail about enamel coating.
3. Have studied the concept of vapour phase coatings.
4. Have studied about the various special coating techniques.
5. Have studied the properties and applications of special coatings.

Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MM4110	Introduction to Crystal Elasticity and Crystal Plasticity	PEC	3-0-0	3

Course Learning Objectives:

1. Introduces the structure and properties of different types of materials
2. Explains the Elasticity of materials
3. Acquire knowledge about continuum plasticity and crystal plasticity
4. Explains hardening mechanisms in metals
5. Describes multiscale approach to materials modelling

UNIT 1

Introduction, different types of materials, crystallographic directions and planes, structure of crystalline solids

UNIT 2

Orientation dependence of elastic response in cubic and no cubic crystals. Three dimensional states of stress and strain, principal stresses, small strains

UNIT 3

Plastic deformation in tension and compression, Baschinger effects, yield criteria, plasticity models - anisotropic plasticity, isotropic and kinematic hardening

UNIT 4

Crystal imperfections, dislocation geometry and energy, dislocation mechanics, slip system yield criteria, flow rule, hardening rule

UNIT 5

Deformation of polycrystals, texture strengthening, effect of crystal structure and grain size; Strain-hardening, solid solution strengthening, dispersion strengthening, precipitation hardening

UNIT 6

Different homogenization methods from single to polycrystals

REFERENCE BOOKS

1. D.W.A. Rees, Basic Engineering Plasticity, Elsevier India, New Delhi, 2008.

2. C Lakshmana Rao and Abhijit P Deshpande, Modelling of Engineering Materials, Ane Books Pvt. Ltd., New Delhi, India, 2010.
1. 3.John D. Verhoeven, Fudamentals of Physical Metallurgy, Wiley, 1975.
2. 4.TH Courtney, Mechanical Behaviour of Materials, 2nd eds, McGraw-Hill International eds, 2000.
6. G E Dieter, Mechanical metallurgy, 3rd revised eds, Mgh, 1989.
3. 6.Donald R. Askeland and Pradeep P. Phule, The Science and Engineering of Materials, 4th Eds, Thomson, Singapore, 2003.
7. J. Chakrabarty, Theory of plasticity, 3rd Eds, Elsevier India, 2009.
8. Robert E. Reed-Hill, Physical Metallurgy Principles, 2nd Editions, East-West Press Pvt. Ltd, New Delhi, 2008.

Course Outcomes:

1. Understanding fundamentals of structure and properties of various materials
2. Ability to get an idea on continuum and crystal plasticity
3. Able to describe hardening mechanism and multi scale approach to material modelling.

Assessment Method

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MM4111	Super alloys	PEC	3-0-0	3

Course Objectives:

1. Acquire knowledge about super alloys and knowing the applications of super alloys.
2. Understanding the microstructure of wrought heat resistant alloys, Ni-base & Co-base alloys.
3. Understanding the dependency of properties on microstructure of super alloys.
4. Acquiring the knowledge of melting and forming methods involved in production of super alloys.

Unit-1 :

Introduction to super alloys, Guide to selection of super alloys, Wrought Super alloys, Heat resistant Castings.

Unit-2 :

Microstructure of Wrought Heat –Resistant Alloys, Microstructure of Ni-base & Co-base heat resistant casting alloys. Temperature and Time-dependent Transformation. Application to Heat Treatment of High temperature Alloys.

Unit-3 :

Relationship of properties to Microstructure in super alloys. Fracture properties of super Alloys. High temperature corrosion and use of castings for protection. Effect of physical metallurgy and process variables on the microstructure of wrought super alloys. Process and Metallurgical factors affecting on super alloys and other high temperature materials.

Unit-4 :

MELTING PROCESS: Melting of super alloys: Principles and practices of vacuum Induction. Melting and Vacuum Arc Re-melting.

Unit-5 :

FORMING METHODS: Forming and fabrication of Super alloys: Recent developments in

P/M of super Alloys-Production of components by Hot-Isostatic pressing. Casting Methods- Improving turbine blade performance by solidification control-The development of single crystal turbine blades.

Unit-6 :

Quality of super alloys casting: Heat Treating of Heat resistant alloys.

Text books:

1. Super alloys: Source book: Mathew J.Donachie .Jr.Editor:1984
2. The Super alloys: edited by Chester T.Sins and William C Haagel: 1972.Campbell IE 3.High temperature technology, John wiley and Sons Inc.;1956

Course Outcomes:

By the end of this course, students will be able to

1. Acquire knowledge about super alloys and knowing the applications of super alloys.
2. Study the microstructural aspects of wrought heat resistant alloys, Ni-base & Co-base alloys and correlate properties of super alloys with their microstructure.
3. Identify different melting and forming methods involved in production of super alloys.

Assessment Method

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MM4112	Fuels, Furnaces, Refractories	PEC	3-0-0	3

Course Learning Objectives:

1. To understand concepts of various concepts related the fuels- solid fuels and theory of formations and characterizations. Production of coal in the view of metallurgical orientation.
2. To understand about the production and classifications of liquid fuels, gaseous fuels.
3. To understand the production of CWG, LD, coke oven and BF gases, the combustion and flame temperature problems.
4. Detail discussion on Refractories- Definition, Properties, classification. Manufacture, properties and applications towards metallurgical orientation.
5. To understand the Heat transfer, Refractory Design, Role of refractory surfaces, pyrometer and heat transfer systems**.**
6. Indetail discussions on Heat losses in furnaces and furnace efficiency- Sankey diagrams. Principles of waste heat recovery.

Course Content:

Unit - 1

Solid fuels. Classification. Theories of formation of coal.Study types and properties of coal. Proximate analysis & ultimate analysis of coal. Carbonization of coal. Coke and by products. Testing and properties.

Unit - 2

Liquid fuels. Classification of formation of petroleum. Petroleum refining. Distillation. Bergius process. Fischer-Trospesch process. Coal tar fuels. Testing and properties. Gaseous fuels.Classification. Production of PG, WG.

Unit - 3

Production of CWG,LD gas, Coke oven gas and BF gas. Industrial gasification processes. Lurgi, Winklers and Kopper, Totzek processes. Properties and testing. Liquid and gaseous fuel burners. Combustion and flame temperature problems.

Unit - 4

Refractories- Definition, Properties, classification and general description. Manufacture, properties and applications of Alumino-silicate, Silica, Dolomite, Magnesite, Chromite and Carbon refractories.

Unit - 5

Furnaces- Classification of furnaces and their use in metallurgical industries. Elements of heat transmission. Steady state conduction, convection and radiation. Heat utilization in furnaces, available heat, factors affecting it.

Unit - 6

Heat losses in furnaces and furnace efficiency. Heat balance and Sankey diagrams. Principles of waste heat recovery. Recuperators and regenerators. Types and applicability. AMTD and LMTD in recuperators. Protective atmosphere and their applications. Salt bath furnaces.

Learning resources

Text book:

1. Fuels, Furnaces and Refractories by O.P.Gupta,Khanna Publishers

Reference Books:

1. Elements of fuel technology –HIMUS
2. Fuels Furnaces, Refractories& Pyrometry-A.V.K.Surya Narayana.
3. R. Schuhmann: Metallurgical Engineering, Vol.1 Engineering Principles
4. P.Mullinger and B. Jenkins: Industrial and Process Furnaces
5. D.R.Poirier and G.H.Geiger: Transport phenomena in materials processing.

Web resources:

1. https://nptel.ac.in/courses/113104058/mme_pdf/Lecture1.pdf

Course outcomes: The outcomes at the end of this course are as follows:

1. The student will understand the origin, classification and analysis of industrial fuels.
2. The student able to know the Manufacture and testing of metallurgical coke along with the properties.
3. The student will understand the production and principles of fuel oil, fuel gases and their uses.

4. The student will able to understand the heat transfer system through various bodies. Problems solving and study of different furnaces.
5. The student able to understand various types of pyrometers used in industry.
6. The student will able to study on different types of Refractories materials, their manufacturer, properties and industrial users.

For Theory courses only:

Course Nature		**Theory**		
		Assessment Method		
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	**Course Name**	**Course Category**	**L-T-P**	**Credits**
20MM4201	**Thermo-mechanical and Thermo Chemical processing**	**PEC**	**3-0-0**	**3**

Course Learning Objectives:

1. To understand fundamentals of thermo mechanical and thermochemical processing of materials
2. To learn mathematical modeling of thermo mechanical and thermochemical processing
3. To understand structure and properties development during thermo mechanical and thermochemical processing

Course Content:

Unit-I : **(12 Hrs)**

Introduction to Hot deformation processes, Flow curves as a function of strain rate and temperature, Stress, strain, strain rate sensitivity, Microstructural evolution, Recovery, Recrystallization , Dynamic recrystallization, DDRX, CDRX, GDRX

Unit-II: **(8 Hrs)**

Texture, Deformation texture (BCC), Deformation texture (FCC), Recrystallization texture (BCC), Recrystallization texture (FCC),

Unit-III: **(10 Hrs)**

Constitutive analysis, Low strain rate , Medium strain rate, High strain rate, Deformation maps, Processing maps, Different models, Interpretation, Processing maps microstructure correlation

Unit-IV: **(10 Hrs)**

SPD based thermo-mechanical processes, Friction stir Processing, Equal Channel Angular Processing, High pressure torsion,

Unit-V: **(12 Hrs)**

Introduction to Thermochemical surface treatments, Thermodynamics of Gas/solid equilibrium, Kinetics of reactions; heterogeneous reactions at surfaces and inward diffusion into solids

Unit-VI: **(8 Hrs)**

Nitriding treatments; Gaseous/salt-bath/plasma, Carburizing treatments; Pack/Gas/Plasma/Salt-bath, Low temperature processes for stainless steels

Learning resources

Text book:

1. Bert Verlinden, Julian Driver, Indradev Samajdar, Roger D. Doherty, "ThermoMechanical Processing of Metallic Materials" Pergamon Press, 2007
2. Cemil Hakan Gur, Jiansheng Pan "Handbook of Thermal Process Modeling Steels" CRC Press, 2009
3. Eric J. Mittemeijer, Marcel A. J. Somers "Thermochemical Surface Engineering of Steels" Elsevier Science, 2018 **Course outcomes:**

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

1. Select suitable thermo mechanical and thermo chemical processes for a given materials
2. Explain metallurgical and mechanical properties development during the thermo mechanical and thermochemical process

Assessment Method

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MM4202	Nuclear Materials	PEC	3-0-0	3

Course Learning Objectives:

1. To explain and describe the basics of nuclear technology and relevance of metallurgy to nuclear interactions and reactions.
2. The studies on radiation effects and thermal cycling on fissile and non-fissile materials.
3. To explain Reactor Components: Types and classifications of reactors. Materials for Nuclear Reactors.
4. The studies on Control rods, reflectors and shielding materials. Production and processing of Reactor Materials.
5. To gain a working knowledge of extraction and commercial production methods of nuclear metals like Uranium, Thorium, and Beryllium.
6. In detail studies on Nuclear Power Production in India and its economics

Course Content:

Unit-I :

Elementary Nuclear Physics and Chemistry: Structures of nucleus, radioactivity, bending energy: nuclear interaction: fission and fusion: nuclear reaction: energy, release and chain reactions: neutron cross-section: multiplication and criticality concepts and factors.

Unit-II:

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

Unit-III:

Reactor Components: Types of reactors and classifications. Materials for Nuclear Reactors: Considerations in selection and properties of common materials used as fuels, their physical and chemical properties: canning materials: coolants.

Unit-IV:

Control rods: reflectors and shielding materials. Production of Reactor Materials: Occurrence and general characteristics of nuclear minerals. Indian Resources: Flow sheets of processing of nuclear minerals for the production of nuclear grade uranium.

Unit-V:)

Flow sheets of processing of nuclear minerals for the production of nuclear grade Thorium, beryllium and zirconium with emphasis on basic scientific principles involved.

Unit-VI:

Production and enriched uranium and fabrication of fuel elements. Processing of irradiated fuel for recovery of plutonium. Nuclear Power Production in India and its economics

Learning resources

Text book:

1. Metallurgy in Nuclear Power Technology: Wright JC, Iliffe Book Ltd., 1962.
2. Nuclear Reactor Metallurgy: Wilkinson WD and Murphy WF, Van Nostrand, 1958.

Reference Books:

1. Principles of Nuclear Reactor Engineering: Glasstone S and Snesonske A Macmillan, London.
2. Uranium and Thorium: Grainger L; George Newnes Ltd., London.
3. Nulcears Fuels: Gurinsky DH and Dienes JL; Macmillan.

Web resources:

1.https://nptel.ac.in/courses/112101007/downloads/Lecturenotes/Lecture1.pdf1

Course outcomes:

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

1. The student willget idea about the working of nuclear reactors and applications in nuclear reactor.
2. The student will be acknowledged with the Elementary Nuclear Physics and Chemistry involved in nuclear materials.
3. The student able to know the Justify the extraction techniques adopted for Uranium, Beryllium, Thorium and Zirconium.
4. The student will understand the processing of nuclear minerals for the production of nuclear grade Uranium, Thorium, beryllium and zirconium.
5. The student will able to understand the Nuclear Power Production in India and its economics.

Assessment Method

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	**Course Name**	**Course Category**	**L-T-P**	**Credits**
20MM4203	**Polymer Blends and Alloys**	**PEC**	**3-0-0**	**3**

Course Learning Objectives:

1. To teach basic phase separation concept in polymer blends, alloys and composites.
2. To deliver the structure-property relationship of polymer blends and alloys
3. To explore various types of polymer blend and alloys available in the polymer field.
4. To understand the recent developments in the field of Polymer blends and alloys
5. To understand the design and processing of blends in the field of polymeric materials.

Course Content:

Unit – 1:

Alloying & blending – definition - need to alloy & blend polymers - polymer that can be blended - introduction to composites - raw material selection criteria.Introduction: historical outline of industrial development of polymer alloys and blends-definitions-the reasons for and methods of blending-how to select blend components-fundamental principles for development of polymer alloys and blends.

Unit – 2:

General principles of phase equilibria calculation-theories of liquid mixtures containing polymer: Huggins- Flory theory, equation of state theories, Gas-lattice model, etc; Mechanisms of phase separation-general types of Polymer blends-polymer crystallization-morphology of blends-measurement of polymer/polymer interaction.

Unit – 3:

Blend Preparation equipment's: mixers and their various types like banbury, hot and cold mixers, twin screw compounders, and two- roll mills, etc. Design features of these equipment's like rotor types, screws and their various types; flow behavior of the plastic material in the mixing equipment's, theory of mixing etc.

Unit – 4:

Mechanical properties (tensile strength, tensile modulus, elongation, toughness, compressive strength, rigidity, fracture mechanics, thermal properties, flammability, electrical and optical properties, bio-durability of blends.

Unit – 5:

Characterization techniques like differential scanning Calorimetric, Thermo Gravimetric Analysis, DTA, UVIR, FTIR, Scanning Electron micrographs, X-ray Analysis etc.,

Unit – 6:

Blends of engineering and commodity plastics like PVC/ABS, PVC/SAN, PVC/NBR, PC/PET, PC/PBT, PC/ABS; PPO/HIPS etc. study in detail along with properties and applications.

Learning resources

Text book:

1. Polymer Alloys and Blends by L.A.Uttracki.

Reference Books:

1. Polymer Engineering and Science Encyclopedia 2.

Polymer Blends and alloys – G.O.Shonaike, G. P. Simon

3. Polymer Blends and alloys – M.J.Folkes, P.S. Hope.

Web resources:

1. https://nptel.ac.in/courses/102106057/31
2. www.mit.edu

Course outcomes: The outcomes at the end of this course are as follows:

1. The student willunderstand concepts of polymer alloying and blending
2. The student able to understand the compatibility of various systems of polymers

3.The student will Identify which testing methods to be used for polymer alloys and blends

4.The students will be able to understand challenges in making polymer blends and alloys

For Theory courses only:

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	**Course Name**	**Course Category**	**L-T-P**	**Credits**
20MM4204	**Welding Metallurgy**	**PEC**	**3-0-0**	**3**

Course Learning Objectives:

1. To develop understanding of metallurgical fundamentals of welding with regard to heat
2. flow, and phase transformations during welding.
3. To study Welding of ferrous metals and alloys
4. To study Welding of non ferrous metals and alloys.
5. To gain a knowledge about quality control methods in welded joints **Course Content:**

Unit – 1:

Heat flow - temperature distribution-cooling rates - influence of heat input, joint geometry,plate thickness, preheat, significance of thermal severity number

Unit – 2:

Weld metal solidification - columnar structures and growth morphology- effect of welding parameters - absorption of gases - gas/metal and slag/metal reactions.

Unit – 3:

Phase transformations- weld CCT diagrams - carbon equivalent-preheating and post heating- weldability of low alloy steels, welding of stainless steels use of Schaffler and Delong diagrams, welding of cast irons

Unit – 4:

Welding of Cu, Al, Ti and Ni alloys – processes, difficulties, microstructures, defects and remedial measures.

Unit – 5:

Origin and types of process induced defects, - significance - remedial measures, hot cracking - cold cracking -lamellar tearing - reheat cracking - weldability tests - effect of metallurgical parameters.

Unit – 6:

Blends of engineering and commodity plastics like PVC/ABS, PVC/SAN, PVC/NBR, PC/PET, PC/PBT, PC/ABS; PPO/HIPS etc. study in detail along with properties and applications.

Learning resources

Reference Books:

1. Linnert G. E.,'Welding Metallurgy', Volume I and II, 4th Edition, AWS, 1994
2. Granjon H., 'Fundamentals of Welding Metallurgy', Jaico Publishing House, 1994
3. Kenneth Easterling, 'Introduction to Physical Metallurgy of Welding', 2nd Edition, Butterworth Heinmann, 1992
4. Saferian D., 'The Metallurgy of Welding', Chapman and Hall, 1985
5. Jackson M. D., 'Welding Methods and Metallurgy', Griffin, London, 1967 6. Mishra. R.S and Mahoney. M.W, Friction Stir Welding and Processing, ASM, 2007
7. Welding Metallurgy – Sindo Kour, 2nd edition, published by Wiley.

Course outcomes: The outcomes at the end of this course are as follows:

1. Basic theoretical & practical knowledge of welding of ferrous metals and alloys 2. Basic theoretical & practical knowledge of welding of non ferrous metals and alloys
3. Conduct quality control tests on welded joints**.**

For Theory courses only:

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MM4205	**Additive Manufacturing**	**PEC**	**3-0-0**	**3**

Course Learning Objectives:

1. To make understand the importance of additive manufacturing technology and its innovation.
2. To have proper knowledge on various additive manufacturing processes.
3. To understand the problems of a component during its manufacturing.
4. To understand the steps and difficulties involved in additive manufacturing process to produce a component.
5. To make understand the difference between the additive manufacturing and conventional manufacturing.
6. To make understand the latest trends and opportunities in additive manufacturing field

Course Content:

Unit – 1:

Introduction, Prototyping fundamentals, Historical development, Advantages of AMT,

Commonly used terms, process chain, 3D modelling, Data Conversion, and transmission, Checking and preparing, Building, Post processing, RP data formats, Classification of AMT process, Applications to various fields

Unit – 2:

Stereo lithography apparatus (SLA): Models and specifications, process,working principle, photopolymers, photo polymerization, layering technology, laser and laser scanning, applications,advantages and disadvantages, case studies.

Unit – 3:

Solid ground curing (SGC): Models and specifications, process, working ,principle, applications, advantages and disadvantages, case studies. Laminated object manufacturing(LOM): Models and specifications, Process, Working principle, Applications, Advantages and disadvantages, Case studies.

Unit – 4:

Fused Deposition Modeling (FDM): Models and specifications, Process, Working principle,
Applications, Advantages and disadvantages, Case studies, practical demonstration

Unit – 5:

Selective laser sintering (SLS): Models and specifications, process, working principle, applications, advantages and disadvantages, case studies.

Unit – 6:

Three dimensional printing (3DP): Models and specification, process, working principle, applications, advantages and disadvantages, case studies.

Learning resources

Reference Books:

1. Chua C.K., Leong K.F. and LIM C.S Rapid prototyping: Principles an Applications, World
Scientific publications, 3rdEd., 2010

2. D.T. Pham and S.S. Dimov, “Rapid Manufacturing”, Springer, 2001

3. Terry Wohlers, “ Wholers Report 2000”, Wohlers Associates, 2000

4. Paul F. Jacobs, “ Rapid Prototyping and Manufacturing”–, ASME Press, 1996

5. Ian Gibson, Davin Rosen, Brent Stucker “Additive Manufacturing Technologies, Springer, 2nd Ed, 2014.

Course outcomes: The outcomes at the end of this course are as follows:

1. Know various additive manufacturing processes.
2. Know the type of additive manufacturing process one has to adopt for producing
3. a component.
4. Know the advantages and limitations of a given process to produce a component.

5. Know the importance of materials used for producing a designed component.
6. Know how additive manufacturing is different from conventional manufacturing
7. processes.

For Theory courses only:

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	**Course Name**	**Course Category**	**L-T-P**	**Credits**
20MM4206	**Fracture Mechanics and Failure Analysis**	**PEC**	**3-0-0**	**3**

Course Content:

Unit – 1:

The geometry of stress and strain, elastic deformation, plastic and elasto-plastic deformation - limit analysis.

Unit – 2:

Two dimensional elastic fields – Analytical solutions yielding near a crack front – Irwin's approximation - plastic zone size – Dugdaale model – J integral and its relation to crack opening displacement

Unit – 3:

Griffith analysis – Linear Fracture Mechanics-Crack Opening displacement – Dynamic energy balance – crack arrest.

Unit – 4:

Empirical Relation describing crack growth by fatigue – Life calculations for a given load amplitude – effects of changing the load spectrum – Effects of Environment.

Unit – 5:

Examples of crack-growth Analysis for cyclic loading - leak before break – crack Initiation under large scale yielding – Thickness as a Design parameter – crack instability in Thermal or Residual – stress fields.

Unit – 6:

Fractographic analysis of ductile, brittle, fatigue and high temperature fractured surfaces. Failure Analysis: Steps involved in it. Case studies of some engineering failures.

Learning resources

Text Books:

1. Norman E. Dowling,“ Mechanical Behavior of Materials”, 2nd Edition, Prentice-Hall 1999

Reference Books:

1. David Broek, “Elementary Engineering Fracture Mechanics“, Fifthoff and Noerdhoff International Publisher, 1978.
2. Kare Hellan,“Introduction of Fracture Mechanics”, McGraw-Hill Book Company, 1985.
3. Preshant Kumar, “Elements of Fracture Mechanics”, Wheeler Publishing, 1999.
4. Suresh, S.,“ Fatigue of Materials”, Cambridge University Press, 2 nd edition, 1998.
5. Ashok Saxena,“ Nonlinear Fracture Mechanics for Engineers”, CRC Press, 1998.
6. Schive, Jaap, “Fatigue of Structures and Materials”, Kluwer Academic Publishers, 2001.

For Theory courses only:

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Open Elective course syllabus

Course code	Course name	Course Category	L-T-P	Credits
20MMXX01	Biomaterials	OEC	3-0-0	3

Course Learning Objectives:

1. To understand the fundamental concepts of biomaterials science.
2. To understand the cell-material interaction and foreign body response.
3. Evaluation and assessment of this compatibility and genotoxicityof biometals.
4. To understand the processing and properties of different bioceramic materials.
5. To understand the structure and properties of different polymers.
6. To understand the design concepts of bio-implants.

Course Content:

Unit -1 :
(6 Hrs)

Introduction to basic concepts of biomaterials science, salient properties of important material classes; overview of body environment, manufacturing and properties of metals, ceramics, polymers and composites, concept of biocompatibility, host response, structure-property of biological cell. property requirement of biomaterials, protein and cellular adaptation process, cell structure and properties of biological cells & tissues, cell migration and cell division and cell death.

Unit -2 : (9 Hrs)

Cell material interactions and foreign body response, cell differentiation and cell death, cell apoptosis, assessment of biocompatibility of biomaterials, structure and properties of

protein; cell - material interaction, in vitro biochemical assays (cellular adhesion, cellular viability using MTT, osteogenic differentiation using ALP assay; Biomineralisation using osteocalcin assay), assessment of biocompatibility of biomaterials, biological testing (hemocompatibility, tribological testing), structure and properties of bone as well as in vivo testing and histocompatibility assessment, important biometallic alloys.

Unit -3 :
(6 Hrs)

In vivo testing and histocompatibility assessment, Ti Alloy, Co-Cr-Mo alloys, Genotoxicity assessment (physical damage to DNA by biomaterial eluates), bioceramics, important biometallic alloys: Ti-based, stainless steels, Co-Cr-Mo alloys, processing of bioceramics, ceramics, bioceramics and glasses, sintering and mechanical properties of ceramics.

Unit -4 : (12 Hrs)

Bioinert, bioactive and bioresorbable ceramics, fracture and toughening of ceramic composites, development of based bioceramic composites for hard tissue replacement, alternative phosphate materials, based composites with bactericidal property and glass ceramics for dental restoration, processing and properties of different bioceramic materials with emphasize on hydroxyapatite, electrostatic spraying of UHMWPE-HA-CNT composites, thin films and coatings, thermal spray coatings, synthesis of biocompatible coatings on structural implant materials, biocompatibility of plasma sprayed cnt reinforced hydroxyapatite biocomposite coatings, biocompatibility of alumina and cnt reinforced hydroxyapatite.

Unit -5 :
(6 Hrs)

Plasma spraying of carbon nanotube reinforced hydroxyapatite on Ti-6Al-4V substrate,glassceramics for dental restoration applications, structure and properties of polymersbiodegradable polymers (Importance), microstructure and properties of glass-ceramicsbiodegradable polymers (Types), mechanisms of bioerosion.

Unit -6 : (6 Hrs)

Biodegradable polymers, external field and material interaction, tissue engineering and wound healing, understanding design concepts of bio-implants, design concept of developing new materials for bio-implant applications, understanding design concepts of dental-implants, understanding design concepts of orthopedic-implant.

Learning resources
Text book:

1. Ratner, Hoffman, Schoet, Lemons Biomaterials Science: An introduction to Materials in Medicine, Elsevier Academic Press, Second Edition, 2004.

2. Mithe, Ritchie, Karihalo, Comprehensive structural interity,Vol.9: 2003.

Reference Books:

1. Fredrick H. Silver and David L. Christiansen, Piscataway, Biomaterials Science and Biocompatability, Springer, New Jersey.
2. JM Davis, Basic Cell Culture: A Practical Approach, IRL Press, Oxford University Press, New York, 1994.

Web Resources:

1. 1. NPTEL : https://nptel.ac.in/courses/113104009/

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

1. Well understanding of properties of biomaterials.
2. Evaluation of the biocompatibility and assessment of biocompatibility of biomaterials.
3. Well understanding of properties and processing of bio-ceramics.
4. Knowledge about the biocompatible coatings on structural implant materials.
5. Well understanding of structure and properties of polymers Biodegradable polymers.
6. Basic knowledge about design concept of developing new materials bio-implants.

Assessment Method

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MMXX02	Composite Materials	OEC	3-0-0	3

Course objectives:

1. Introduces the composite materials and their classification
2. Acquire knowledge about Characterization of Composites
3. Explains the fabrication, properties and applications of MMC& PMC
4. Explains the fabrication, properties and applications of CMC& CCC
5. Explains fracture mechanics and fracture toughness in composites

Course Content:

UNIT 1

Introduction to Composites, Matrices, Reinforcements, Classifications, Applications, Advantages, Fundamental concept of reinforcement, review of current developments; design fabrication and economic considerations;

UNIT 2

Basic mechanics of reinforcement, Stiffness of parallel arrays of fibres in a matrix. Discontinuous and particulate reinforcement. Fibres and resin materials. Rule of Mixtures, Critical Fiber Length, Short and Continuous Fibers, Fiber Orientation; Matrix and

Reinforcement Materials, Polymeric Matrices, Metallic Matrices, Ceramic Matrices, Particulates, Flakes, Whiskers, Fibers: C, B, Glass, Aramid, Al2O3, SiC, Nature and manufacture of glass, carbon and aramid fibres.

UNIT 3

Review of the principal thermosetting and thermoplastic polymer matrix systems for composites. ; Polymer Matrix Composites (PMCs), Metal Matrix Composites (MMCs), Ceramic Matrix Composites (CMCs), CFRP & Carbon/Carbon Composites (CCCs); Types,
Manufacturing, Processing methods, Interfaces, Properties, Applications, Toughening Mechanisms, Fiber Forms, Prepregs, Molding Compounds- Processes, Lay- Ups, Filament Winding, Pultrusion, Recycling.

UNIT 4

Matrix –Reinforcement Interface, Wettability, Interactions at Interface, Interfacial Bonding Types, Interfacial Strength Tests, The role of the interface. The nature of fiber surfaces, wetting and adhesion

UNIT 5

Strength, Stiffness, Fracture, Toughness and toughening mechanisms of composites Strengths of unidirectional composites. Multiple fracture in laminates. Macroscopic fracture and energy dissipating processes. Application of fracture mechanics to composite materials.

UNIT 6

Fracture Mechanics and Fracture Toughness in Composites, Linear Elastic fracture mechanics, Toughness, Fiber matrix debonding, Fiber Pullout Buckling and Post- Buckling; Failure criteria, Fatigue and Creep in composites, Environmental effects in Composites, Green composites; Synthesis and Properties of Nanocomposites.

Learning resources

Reference Books:

1. Chawla, Composite Materials: Science and Engineering, Springer, 2nd Ed. 1998.
2. Matthews & Rawlings, Composite Materials: Engineering and Science, Chapman & Hall, 1994.
3. Hull, An Introduction to Composite Materials, Cambridge, 2nd Edt. 1997.Bhat, S.V., Biomaterials, 2nd edition, Narosa Publishing, 2006

Course outcomes :

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

1. Understand the classification of Composite materials

2. Explain the characterisation of Composite materials
3. Describe the fabrication methods of all the four types of composite materials
4. Expalin the properties of all the four types of composite materials
5. Explain the applications of all the four types of composite materials.

Assessment Method

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	**Course Name**	**Course Category**	**L-T-P**	**Credits**
20MMXX03	**Diffusion in Solids**	**OEC**	**3-0-0**	**3**

Course Learning Objectives:

1. To provide knowledge on thermodynamics to understand the driving force for diffusion.
2. To understand about the Fick's laws and its applications.
3. To gain knowledge of how the chemical potential gradient influences the diffusion.
4. To study the atomic mechanisms in solids
5. To study about the different kinds ofdiffusion parameters.
6. To find out the diffusion in ternary and multicomponent systems and its phase diagrams. **Course Content:**

Unit-1:

Concept of free energy, enthalpy and entro. Gibb's free energy change with temperature in a single component system. Thermodynamic parameters in a binary system. Thermodynamics and phase diagram. Concept of the chemical potential and the activity of elements. Point defects: Equilibrium vacancy concentration in a pure element. Equilibrium concentration of interstitial atoms. Defects in the ordered phases. Calculation of thermodynamic parameter

Unit-II:

Fick's laws of diffusion and thin film solution. Solution in seminfinite diffusion couples (error function analysis). Solution for homogeneization (separation of variables)

Unit-III:

The composition profilesin an interdiffusion zone anddiffusion as a tool to make products. Diffusion under the thermodynamic driving forces. Driving force for diffusion and Fick's laws of diffusion. Product phase formations because of diffusion in real systems. Diffusion process as a tool to make products. Definition and description of different diffusion terms

Unit-IV:

Interstitial diffusion. Concept of random walk. Substitutional diffusion. Activation energy for diffusion. Orientation dependence. Diffusion in the ordered phases.

Unit-V:

Matano-Boltzmann analysis. Calculation of diffusion parameters using the MatanoBoltzmann analysis. Den Broeder and Wagner's approach. Problem of finding the initial contact plane. Effect of molar volume in a hypothetical diffusion couple. The Kirkendall effect. The intrinsic diffusion coefficients: Darken analysis and the van Loo relation. Integrated diffusion coefficient. Calculations of the integrated diffusion coefficients. Tracer diffusion coefficient and the vacancy wind effect. Recent developments on the Kirkendall effect. Physico-chemical approach. Grain boundary diffusion.

Unit-VI:

Ternary phase diagrams. Ternary and multicomponent diffusion. Intrinsic, integrated and the average diffusion coefficients. Phase diagram determination by the diffusion couple technique.

Learning resources

Reference Books:

1. D.A.Porter, K.E.Easterling,"Phase Transformation in Metals and Alloys", 3rd Edition.
2. P. Shewmon, Diffusion in Solids

3. Doru Michael Stefanescu,Science & Engineering of Casting Solidification, Springer,
4. J. Philibert, Atom movements: Diffusion and mass transports in solids.
5. Metals Handbook, Casting, vol. 15, 10th Edition, ASM Int, Materials Park, Ohio,
6. M. C. Flemings: Solidification processing, McGraw-Hill, 1974. **Course outcomes:**

On successful completion of the course, student will be able to do

1. Determine the driving force for diffusion.
2. Explain the Fick's laws and its applications.
3. Understand the influences of chemical potential gradient on diffusion.
4. Know the atomic mechanisms in solids.
5. Analyze the influence of different kinds of diffusion parameters on diffusion.
6. Examine the diffusion in ternary and multicomponent systems.

Assessment Method:

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MMXX04	**Electron Microscopy**	**PEC**	**3-0-0**	**3**

Course objectives:

1. This course at the under graduate level on microstructural characterization of materials.
2. This course will cover the basic principles and techniques of optical and electron microscopy (Scanning electron microscopy and Transmission electron microscopy) along with demonstrations on the instrument details and imaging experiments.

3. This course also deals with the sample preparation techniques for the micro-structural analysis.

Course Content:

Unit-1

Human eye, optical microscope, transmission electron microscope (TEM), scanning electron microscope (SEM), scanning transmission electron microscope (STEM), analytical electron microscopes, scanning-probe microscopes

Unit-2

The electron gun, imaging system, theoretical limit, chromatic and spherical aberration, astigmatism, dept of field/focus, kinematics of scattering by atomic nuclei, electron-electron scattering, scattering contrast from amorphous and polycrystalline specimen, dark-field images, selected area diffraction technique, phase contrast, specimen preparation

Unit-3

Inelastic and elastic electron scattering, Kikuchi patterns, absorption and phase contrast, diffraction contrast, dynamical theory and solution for perfect crystal, grain boundary fringes, stacking fault fringes, Moiré fringes, dislocations, small loops, vacancy aggregates, precipitates

Unit-4

Operating principle, depth of field, noise, resolution, penetration of electrons into a solid, secondary-electron image, backscattered-electron image, other imaging modes, specimen preparation, environmental SEM, electron-beam lithography

Unit-5

The Bohr atom model, X-ray emission spectroscopy, X-ray energy-dispersive spectroscopy, quantitative analysis in the TEM and SEM,

Unit-6

X-ray wavelength-dispersive spectroscopy, auger electron spectroscopy (AES), electron energy-loss spectroscopy (EELS)

Learning resources

Reference Books:

1. Goodhew, P.J., Humphreys, J. and Beanland, R., “Electron Microscopy and Analysis”, 3rd Ed., Taylor and Francis,2000
2. Thomas, G., “Transmission Electron Microscopy of Materials”, Techbooks,1990

3. Reimer, L., "Scanning Electron Microscope: Physics of Image Formation and Microanalysis", 2nd Ed., Springer,1998
4. Goldstein, J., Newbury, D.E., Joy, D.C., Lyman, C.E., Echlin P., Lifshin E., Sawyer
L. and Michael, J.R., "Scanning Electron Microscopy and X-ray Microanalysis", 3rd Ed., Springer,2003
5. Carter, C.B. and Williams, D.B., "Transmission Electron Microscopy: A Textbook for Materials Science", 2nd Ed., Springer, 2009
6. Egerton, R., "Physical Principles of Electron Microscopy: An Introduction to TEM, SEM and AEM", Springer, 2010 **Course outcomes:**

1. On successful completion of the course, student will be able to understand the importance of microscopy techniques and analysis of various micrographs.
2. Student will be able to learn the basic principles and techniques of optical and electron microscopy (Scanning electron microscopy and Transmission electron microscopy) along with demonstrations on the instrument details and imaging experiments.
3. Student will also learn how to prepare samples for TEM and SEM

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	**Course Name**	**Course Category**	**L-T-P**	**Credits**
20MMXX05	**Energy Storage Materials**	**OEC**	**3-0-0**	**3**

Course Learning Objectives:

1. This course will cover the fundamental materials science issues central to the solid structure and its interface analysis.

2. To learn general and special materials for energy storage applications.
3. To introduce different types of super capacitors and its mechanisms.
4. To understand different materials thermal, structural analysis.
5. To explore advance materials and its application
6. To provide the possible opportunities in the domains of Materials & Metallurgical Engineering towards nanoscale developments.

Course Content

Unit-1

Introduction: Basics of solid state chemistry, defect structure of solids, surface and interface analysis.

Unit-2

Materials for energy storage: Fuel cells, different types, materials used, mechanism of operation, applications; Solar cells – introduction on photovoltaics, materials used, principle of operation, applications; Storage batteries – battery technology, assembly, electrochemical tests;

Unit-3

Supercapacitors – theory, high power super capacitor from carbon nanotubes; Hydrogen storage materials – mechanism of hydrogen storage.

Unit-4

Material Analysis: Thermal, structural and morphological analysis of the energy storage materials, different experimental techniques used.

Unit-5

Rechargable lithium ion battery: Intercalation compounds, anodes and composite anodes, cathode materials, polymeric electrolyte, currents trends of lithium ion batteries for consumer applications

Unit-6

Nanoscale materials: Nano crystalline materials, nanocomposites, nanotubes, energy storage capacity of the nanostructured materials. Magnetocaloric materials: Different types of materials, application of the magnetocaloric effect.

Learning resources

Text book:

1. Nazri G.A., Pistoia G., Lithium Batteries: Science and Technology, Kluwer Academic Publishers, 2004
2. Kumta P.K., Supercapacitors: Fundamentals, Systems, Applications, Emerging trends, Wiley-VCH Verlag, 2009 **Reference Books:**

1. Markvart T. and Castaner L., Solar cells: Materials, Manufacture and Application, Elsevier, 2003
2. Walker G., Solid State Hydrogen Storage: Materials and Chemistry, Woodhead Publishing, 2008
3. Tishin A.M. and Spichkin, Y.I., The Magnetocaloric Effect and its Applications, IOP publishing, 2003.

Course outcomes:

1. On successful completion of the course, student will be able to understand the importance of microscopy techniques and analysis of various micrographs.
2. Student will be able to learn the basic principles and techniques of optical and electron microscopy (Scanning electron microscopy and Transmission electron microscopy) along with demonstrations on the instrument details and imaging experiments.
3. Student will also learn how to prepare samples for TEM and SEM **Assessment Method:**

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MMXX06	**Nano materials**	**OEC**	**3-0-0**	**3**

Course Content:

Unit - 1

Introduction to nanomaterials and nanostructures including both inorganic and organic materials, Top & Bottom up approaches, Challenges in Nanotechnology, Physical Chemistry of solid surfaces- Surface energy, Electrostatic-Van der Waals attraction potential, Interactions between two particles (DLVO theory), and Steric stabilizationInteractions between polymer layers, Mixed steric and electric interactions.

Unit - 2 Zero-Dimensional Nanostructures/Nanoparticles, Homogeneous nucleation and subsequent growth, synthesis of oxide nanoparticles, Synthesis of metallic and semiconductor nanoparticles - Influences of reduction reagents, Influences of polymer stabilizer, Solgel, Hydrolysis, vapor phase reactions, Solid state phase segregation.

Unit - 3

Fundamentals of heterogeneous nucleation, Heterogeneous nucleation and subsequent growth, Nanoparticles through Heterogeneous Nucleation, kinetically confined synthesis of nanoparticles – Aerosol synthesis, Spray paralysis, Template Based synthesis, and Growth termination processes.

Unit - 4 One dimensional nanostructures: Spontaneous growth, Evaporation- Condensation growth, Dissolution- Condensation growth, Vapor (or solution)-liquid-solid (VLS or SLS) growth, Template-Based Synthesis- Electrochemical deposition, Electrophoretic deposition, Template filling, Electrospinning, Lithography.

Unit - 5

Two dimensional nanostructures: Fundamentals of Film Growth, Physical Vapor Deposition (PVD)-Evaporation, sputtering, the comparison between evaporation and sputtering, Chemical Vapor deposition (CVD) - Typical chemical reactions, Reaction kinetics, CVD methods, Atomic Layer Deposition (ALD), Super lattices, self assembly, Electrochemical deposition, Solgel films.

Unit - 6

Carbon-based nanomaterials-Carbon Fullerenes and Nanotubes, Characterization of nanomaterials - Structural Characterization, Chemical Characterization, Physical Properties of Nanomaterials, Electrical conductivity, applications of nanomaterials

Learning resources

Reference Books:

1. Nanostructures and Nanomaterials –Sysnthesis, Properties and Applications, Cao Guozhong and Wang Ying, World Scientific Publishing.

2. Nanomaterials: An Introduction to Synthesis, Properties and Applications, Dieter Vollath, Wiley, 2008
3. Nanoscale Materials in Chemistry, edited by Kenneth J. Klabunde & Ryan Richards, John Wiley & Sons, 2nd edition, 2009.
4. "No Small Matter: Science on the Nanoscale": Felice C. Frankel and George M. Whitesides, The Belknap Press of Harvard University Press, 2009

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course code:	**Course Name**	**Course Category**	**L-T-P**	**Credits**
20MMXX07	**Nuclear Materials**	**OEC**	**3-0-0**	**3**

Course Learning Objectives:

1. To explain and describe the basics of nuclear technology and relevance of metallurgy to nuclear interactions and reactions.
2. The studies on radiation effects and thermal cycling on fissile and non-fissile materials.
3. To explain Reactor Components: Types and classifications of reactors. Materials for Nuclear Reactors.
4. The studies on Control rods, reflectors and shielding materials. Production and processing of Reactor Materials.
5. To gain a working knowledge of extraction and commercial production methods of nuclear metals like Uranium, Thorium, and Beryllium.
6. In detail studies on Nuclear Power Production in India and its economics.

Course Content:

Unit - 1

Elementary Nuclear Physics and Chemistry: Structures of nucleus, radioactivity, bending energy: nuclear interaction: fission and fusion: nuclear reaction: energy, release and chain reactions: neutron cross-section: multiplication and criticality concepts and factors.

Unit - 2

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

Unit - 3

Reactor Components: Types of reactors and classifications. Materials for Nuclear Reactors: Considerations in selection and properties of common materials used as fuels, their physical and chemical properties: canning materials: coolants.

Unit - 4

Control rods: reflectors and shielding materials. Production of Reactor Materials: Occurrence and general characteristics of nuclear minerals. Indian Resources: Flow sheets of processing of nuclear minerals for the production of nuclear grade uranium.

Unit - 5

Flow sheets of processing of nuclear minerals for the production of nuclear grade Thorium, beryllium and zirconium with emphasis on basic scientific principles involved.

Unit - 6

Production and enriched uranium and fabrication of fuel elements. Processing of irradiated fuel for recovery of plutonium. Nuclear Power Production in India and its economics.

Learning resources

Text books:

1. Metallurgy in Nuclear Power Technology: Wright JC, Iliffe Book Ltd., 1962.

2. Nuclear Reactor Metallurgy: Wilkinson WD and Murphy WF, Van Nostrand, 1958.

Reference Books:

1. Principles of Nuclear Reactor Engineering: Glasstone S and Snesonske A Macmillan, London.
2. Uranium and Thorium: Grainger L; George Newnes Ltd., London.
3. Nulcears Fuels: Gurinsky DH and Dienes JL; Macmillan.

Web resources:

1. https://nptel.ac.in/courses/112101007/downloads/Lecturenotes/Lecture1.pdf1.

Course outcomes: The outcomes at the end of this course are as follows:

1. The student willget idea about the working of nuclear reactors and applications in nuclear reactor.
2. The student will be acknowledged with the Elementary Nuclear Physics and Chemistry involved in nuclear materials.
3. The student able to know the Justify the extraction techniques adopted for Uranium, Beryllium, Thorium and Zirconium.
4. The student will understand the processing of nuclear minerals for the production of nuclear grade Uranium, Thorium, beryllium and zirconium.
5. The student will able to understand the Nuclear Power Production in India and its economics.

Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MTXX08	Semiconductor Materials	OEC	3-0-0	3

Course Learning Objectives:

1. To introduce the semiconductor materials and discussing the properties including the electronic structure, free carrier statistics, optical, crystallography, defects.
2. This covers the doping of the semiconductors and provides students the insight useful for understanding new semiconductor devices and technologies.
3. Provides the insights on defects in the semiconductors and give knowledge on electronic device formation.
4. Provide a knowledge on the doping techniques and characterizations
5. Discusses the wide band gap semiconductors and other properties of semiconductor materials.
6. Covers the semiconductor growth techniques and different types of compound semiconductors and applications

Course Content:

Unit – 1

Introduction, Introduction to chemical bonding and development of band gap, Types of semiconductors. Explanation of density of states, Fermi energy, and band occupancy, related problems.

Unit-2 :

Intrinsic and extrinsic semiconductors, carrier concentration, mobility, temperature dependence, related problems, Metal-semiconductor junctions, Schottky vs Ohmic junctions, Band gap diagrams. I-V characteristics, related problems.

Unit-3 :

p-n junctions, equilibrium and under bias (forward and reverse), Band diagrams. I-V characteristics, Junction breakdown, Juntion diode types, related problems, Defects in Crystalline Semiconductors, Point defects, Line defects, Interface and volume defects

Unit-4 :

Preparation & doping techniques of elemental & compound semiconductors; Different ways of diffusion (empty space diffusion, inter lattice diffusion, change places, Thermal Diffusion, Ion implantation, Process parameters & Characteristics for ion implantation.

Unit 5 :

Narrow and wide band gap semiconductors and their applications in electronics, optical and high temperature applications; thermal and optical properties; magnetic properties- Hall effect in semiconductors, applications of hall effect, direct and indirect bandgap semiconductors.

Unit-6 :

Czochralski (CZ) crystal growth, Bridgman growth method, float-zone (FZ) crystal growth, Optoelectronic devices - Photodiodes, Solar Cells, LED's, and Laser Diodes. Compound semiconductors and applications.

Reference Books:

1. Principles of Electronic Materials and Devices, S.O. Kasap, 3rd Ed, 2. Semiconductor devices: Physics & Technology, S.M.Sze, 2nd Ed, Wiley, 2008.

3. The Materials Science of Semiconductors by Angus

4. Semiconductor material and device characterization by Dieter K. Schroder.

Course Outcomes:

1. Describe the properties of materials and application of semiconductor materials
2. Apply the knowledge of semiconductors to illustrate the functioning of basic electronic devices
3. Classify and describe the semiconductor materials and their special applications
4. Usefulness of doping and exploitation of semiconductors
5. knowledge on the direct and indirect bandgap semiconductors, their transport and optical properties.
6. An understanding of various growth techniques used to fabricate the semiconductors.

Assessment Tool	**Weekly tests**	**Monthly tests**	**End Semester Test**	**Total**
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MTXX09	Material Aspects in Design	OEC	3-0-0	3

Course Content:

Unit – 1

Introduction – relation of materials selection to design – general criteria for selection – performance characteristics of materials – materials selection process – design process and materials selection – economics of materials – recycling and materials selection

Unit-2 :

Role of Processing in Designing – classification of manufacturing processes – types of processing systems – factors determining process selection.

Unit-3 :

Design for manufacturability, assembly, machining, casting, forging and welding

Unit-4 :

Surface finish – texture – dimensional tolerances in fitting – interchangeability – selective assembly – geometric tolerance. Selection of fits and tolerances

Unit 5 :

Stress – Strain diagram – design for strength, rigidity – design under static loading, variable loading, eccentric loading – stress concentration. Design examples with shaft design, spring design and C-frames.

Unit-6 :

Design for brittle fracture, fatigue failure, corrosion resistance. Designing with plastics, brittle materials

Reference Books:

1. Dieter George E, Engineering Design, A materials and processing approach, McGraw Hill, 3rd edition, 2000
2. Bhandari, Design of Machine Elements, Tata McGraw Hill, 2006
3. CES Materials Selector, GRANTA Design and M. F. Ashby, 2007

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total

Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MTXX10	**Creep and Fatigue Behavior of Materials**	**OEC**	**3-0-0**	**3**

Course Content:

Unit – 1

Strength of perfect crystal - Lattice resistance to dislocation movement – Elastic properties of dislocation – Dislocation multiplication – Slip and twinning in crystalline solid.

Unit-2 :

Creep of Solids – Temperature stress – Strain rate relation- Deformation mechanism – Super plasticity deformation mechanism maps – Extrapolation procedure for creep rupture data – materials for elevated temperature rules.

Unit-3 :

Macrofractrography fatigue failures - cyclic stress and strain controlled fatigue – Fatigue life estimation for notched components – Crack initiation mechanisms.

Unit-4 :

Stress and crack lengths correlations with FCP – Fracture modes in Fatigue – Microscopic fracture mechanisms – Crack growth behavior at Δk extremes – Influences – Micro structural aspects of FCP in metal alloys.

Unit 5 :

Typical defects – Microscopic surface examination – metallographic and fractographic examination

Unit-6 :

Component failure analysis – Fracture surface preservation – Cleaning and replication techniques and image interpretation.

Reference Books:

1. 1. Richard. W. Hertzberg,“ Deformation and Fracture Mechanism of Engineering
Materials”, John Willey and Sons, 4th edition, 1996.
2. Anderson, T. L.,“ Fracture Mechanics: Fundamentals and Applications”, CRC Press, 2nd edition, 1995

3. Courtney, T. H.,“ Mechanical Behaviour of Materials”, McGraw-Hill, 1990
4. Jones, D. R. H,“ Engineering Materials 3, Materials Failure Analysis- Case Studies and Design Implications”, Pergamon, 1993.
5. Suresh, S.,“ Fatigue of Materials”, Cambridge University Press, 2 nd edition, 1998.
6. Cadek, J.,“ Creep in Metallic Materials”, Elsevier, 1988.

Assessment Tool	**Weekly tests**	**Monthly tests**	**End Semester Test**	**Total**
Weightage (%)	10%	30%	60%	100%

Minor Engineering syllabus

Course Code	Course Name	Course Category	L-T-P	Credits
20MMM101	Science and Engineering of Materials	PCC	3-1-0	4

Course Content:

Unit – 1

CRYSTAL STRUCTURES: Review of atomic bonds-crystal systems and Bravais lattices, principal metallic crystal systems- BCC, FCC, HCP, atom positions and directions in cubic unit cells, miller indices for crystallographic planes in cubic unit cells, crystallographic planes and directions in hexagonal unit cells, volume, planar and linear atomic density calculations, allotropy, single crystal and polycrystalline materials, anisotropy, X-ray diffraction and determination of crystal structures, non-crystalline solids..

Unit-2

CRYSTALLINE IMPERFECTIONS: Types of point defects, vacancy dependence on temperature, solid solutions, formation of substitutional solid solutions and interstitial solid solutions, line defects-dislocations-edge, screw and mixed dislocations- Burger's vector-slip and twinning. Planar defects-grain boundaries, high angle and small angle grain boundaries, grain size determinations. volume defects. voids in BCC and FCC unit cells.

Unit-3

SOLIDIFICATION OF METALS: Homogeneous nucleation and Heterogeneous nucleation,
growth of crystals in liquid metals and formation of grain structure, grain structure in casting.

Unit-4

PHASE DIAGRAMS: Gibb's phase rule, binary isomorphous alloy systems, non-equilibrium cooling, binary eutectic system, eutectoid, peritectic and monotectic reaction, phase diagrams with intermediate phases and compounds, iron-carbon diagram ternary phase diagrams, development of microstructures.

Unit-5

FERROUS AND NON-FERROUS METALS: Effect of alloying additions on steel (Mn, Si, Cr, Mo, V, Ti & W)- classification of steels (tool steel, stainless)– cast irons – alloy cast irons- Copper and Copper alloys –Aluminum and its alloys- Magnesium and its alloys– Titanium and its alloys- Nickel and Cobalt alloys, properties and applications of these materials

Unit-6

NON-METALLIC AND NEWER MATERIALS: Types, properties and applications: Polymers, Ceramics and Composites– Super conductors, nanomaterials and their properties.

Reference Books:

1. Raghavan V, "Physical Metallurgy - Principles and Practice", PHI Learning Private Limited-New Delhi; 3rd edition, 2015.
2. William D. Callister, Jr., "Materials Science and Engineering an Introduction", John Wiley & Sons, Inc., 2nd Edition, 2007.
3. Donald R. Askeland, Pradeep P. Phule, "The Science and Engineering of Materials", Thomson Learning, 5th Edition, 2007.
4. Reza Abbaschian, Robert E. Reed-Hill, "Physical Metallurgy Principles", Cengage, 4th edition, 2013.
5. Sidney H. Avner, "Introduction to Physical Metallurgy", McGraw Hill Education; 2nd edition, 2017
6. Vijendra Singh, "Physical Metallurgy", Standard Publishers Distributors, New Delhi, 2012.

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MMM102	Additive Manufacturing	PCC	3-0-0	3

Course Content:

Unit – 1:

Introduction, Prototyping fundamentals, Historical development, Advantages of AMT, Commonly used terms, process chain, 3D modelling, Data Conversion, and transmission, Checking and preparing, Building, Post processing, RP data formats, Classification of AMT process, Applications to various fields

Unit – 2:

Stereo lithography apparatus (SLA): Models and specifications, process,working principle, photopolymers, photo polymerization, layering technology, laser and laser scanning, applications,advantages and disadvantages, case studies.

Unit – 3:

Solid ground curing (SGC): Models and specifications, process, working ,principle, applications, advantages and disadvantages, case studies. Laminated object manufacturing(LOM): Models and specifications, Process, Working principle, Applications, Advantages and disadvantages, Case studies.

Unit – 4:

Fused Deposition Modeling (FDM): Models and specifications, Process, Working principle,
Applications, Advantages and disadvantages, Case studies, practical demonstration

Unit – 5:

Selective laser sintering (SLS): Models and specifications, process, working principle, applications, advantages and disadvantages, case studies.

Unit – 6:

Three dimensional printing (3DP): Models and specification, process, working principle, applications, advantages and disadvantages, case studies.

Learning resources

Reference Books:

1. Chua C.K., Leong K.F. and LIM C.S Rapid prototyping: Principles an Applications, World Scientific publications, 3rdEd., 2010
2. D.T. Pham and S.S. Dimov, "Rapid Manufacturing", Springer, 2001
3. Terry Wohlers, " Wholers Report 2000", Wohlers Associates, 2000
4. Paul F. Jacobs, "Rapid Prototyping and Manufacturing"–, ASME Press, 1996
5. Ian Gibson, Davin Rosen, Brent Stucker "Additive Manufacturing Technologies, Springer, 2nd Ed, 2014.

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MMM103	**Materials, Energy Sources and Bonding Mechanisms**	**PCC**	**3-0-0**	**3**

Course Content:

Unit – 1:

Materials for AM: Atomic Structure and Bonding, Nature of Polymers, Thermoplastics and
Thermosetting Polymers, Types of Polymerizations, Properties of Polymers, Degradation of Polymers, Metal and Ceramic Powders, Compaction and Sintering of Powders, Composites, Functionally Graded Materials (FGM's).

Unit – 2:

Laser Beam: Introduction, Electromagnetic Radiation, Energy Levels, Interaction of Radiation and Matter; Generation of Laser beam: Spontaneous and Stimulated Emission, Population Inversion, Resonant Cavity; Properties of Laser Light: Line Width, Beam

Divergence Angle, Coherence, Radiance, Focusing Properties of Laser Radiation, and Power. Types Of Lasers, Laser Optics: Light Beam Deflectors, Q-Switches, Optical Isolators, Beam Profilers, Beam Homogenizers; Laser Beam Interaction with Various forms of Materials; other Applications.

Unit – 3:

Laser Additive Manufacturing (AM): Classification, Processing Philosophy, and Metallurgical Mechanisms Classification of Laser AM Processes and Metallurgical Mechanisms, Laser Sintering (LS), Laser Melting (LM), Laser Metal Deposition (LMD), Classes of Materials for AM and Processing Mechanisms, For LM and LMD—Pure Metals
Powder, For LM and LMD—Alloys Powder, For LS and LMD—Multi-Component Metals/Alloys Powder Mixture, Metal Matrix Composites (MMCs), Material/Process Considerations and Control Methods, General Physical Aspects and Design Strategies of Materials for AM, Microstructural Properties of AM-Processed Parts, Mechanical Properties and Performance Aspects of AM-Processed Parts, Structure/Property Stability of AMProcessed Parts.

Unit – 4:

Electron Beam: Introduction, Wave Properties, and Characteristics - Constructive Interference and Destructive Interference; Generation of Electron Beam: Free Electrons, Cathode, Anode, Control Electrode, Focusing Lens, Deflecting System, Beam Correction System, and Vacuum. Parameters: Accelerating Voltage, Power Density, Beam Current, Lens Current, Focal Position, Beam Speed, Beam Deflection; Process Related Effects: Liquid and Vapour Phases, Effect of Vacuum, Solidification, and Heat Affected Zone, Internal Thermal Stresses; Electron beam Interaction with different forms of Material; other Applications.

Unit – 5:

Electron Beam Technology: EBT in Additive Manufacturing- Powder Bed Fusion-Electron
Beam Melting - Materials - Powder Metallurgy Requirements for EBM – Powder Manufacturing - Gas Atomization - Induction Plasma Atomization - Armstrong Process - Hydride-Dehydride - Characterization - Parameter Development - Build Setup and Process - Latest literature

Unit – 6:

Plasma Arc: Introduction, Basic Properties, Characteristics, and Types; Plasma Production; Parameters; Plasma with Various Forms of Material Interaction; Applications. Other Sources: Ultrasonic, Hybrid, and etc.

Learning resources

Reference Books:

1. Patri K. Venuvinod and Weiyin Ma, Rapid Prototyping: Laser-based and Other Technologies, Springer, 2004.
2. Dongdong Gu, Laser Additive Manufacturing of High-Performance Materials, Springer,2015.
3. K. Thyagarajan, Ajoy Ghatak, Lasers: Fundamentals and applications, 2nd Ed., Springer,2010.
4. Ready, J.F, Industrial applications of Lasers, Academic Press, 2nd Ed., 1997.
5. Willium T Selfvast, Laser Fundamentals, Cambridge Univ. Press, 2008.
6. William M. Steen, Laser Material Processing, Springe, 1991.
7. Schultz H., Electron Beam welding, Woodhead Publishing, 1994.
8. Lieberman M.A. and Lichtenberg A. J., Principles of Plasma Discharge and Materials Processing, Wiley Interscience, 1994.
9. Li Yang · Keng Hsu · Brian Baughman Donald Godfrey · Francisco Medina Mamballykalathil Menon · Soeren Wiener, Additive Manufacturing of Metals: The Technology, Materials, Design and Production, Springer, 2017.

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MMM104	**Mechanical Behaviour and Testing of Materials**	**PCC**	**3-0-0**	**3**

Course Content:

UNIT I

Introduction: Strength of materials-Basic assumptions-elastic and plastic behaviour-Average stress and strain-concept of stress, strain and the types of stresses and strains. Dislocation theory: dislocation types, dislocation loop, dislocations in FCC, BCC and HCP, Stress fields and energies of dislocations forces on dislocations, forces between dislocation-Interaction of dislocations, dislocation multiplication, dislocation pileups, Interaction with points defects.

UNIT II

Fracture: Elementary theories of fracture, Griffith's theory of brittle fracture, Ductile Fracture,

Notch sensitivity. Hardness Test: Methods of hardness testing Brinells, Vickers, Rockwell, Rockwell superficial, Shore and Poldi methods, Microhardness test, relationship between hardness and other mechanical properties**.**

UNIT III

TENSION TESTING: ASTM Standards and specification, Engineering stress & strain, True stress strain curves, Holloman - Ludwig equation, Plastic Instability (Necking), Testing machines-types, testing procedures, properties measured, specimen dimensions, Problems. TORSION TESTING & SHEARING TEST: ASTM Standards and specification Testing Machines and procedures.

UNIT IV

Impact Test: Notched bar impact test and its significance, Charpy and Izod Tests, significance of transition temperature curve, Metallurgical factors affecting the transition temperature, temper embrittlement. DBTT curve and its importance. Fracture toughness testing - COD and CTOD tests.

UNIT V

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

UNIT VI

Creep and Stress Rupture: Introduction, The creep curve, Stress-rupture test, Structural changes during creep, Mechanism of creep deformation, theories of creep. Fracture at elevated temperature, Effect of Metallurgical variables on creep. Wear: Classification and mechanisms of wear, delamination theory, debris analysis, testing methods

Learning resources

Text book:

1. George E Dieter, "Mechanical Metallurgy", McGraw Hill Education, Third edition, 2017.
2. Thomas H.Courtney, "Mechanical Behaviour of Materials", McGraw-Hilll, Boston, 2nd edition, 2000.

Reference Books:

1. Wullf et al, Vol. III "Mechanical Behavior of Materials", John Wiley and Sons, New York, 1983.

2. R.W. Hertzberg, "Deformation and Fracture Mechanics of Engineering Materials",
John Wiley and Sons, 1976.
3. A .K. Bhargava, C. P. Sharma, “Mechanical behaviour and testing of materials”, PHI Learning, First edition, 2011.
4. Suryanarayana, A. V. K., “Testing of Metallic Materials”, Prentice Hall India, New Delhi, 1979
5. Marc A. Meyers, Krishan Kumar Chawla “Mechanical Behavior of Materials” Cambridge University Press, 2008

Assessment Method

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits

20MM3101	**Materials Characterization**	**PCC**	**3-1-0**	**4**

Course Content:

Unit-I :

Introduction, concept of resolution, Airy rings, numerical aperture, magnification, depth of field, depth of focus, lens defects and their corrections, principles of phase contrast – bright-field and dark-field contrast, polarized light microscopy, Quantitative microscopy, estimation of grain size, grain boundary area, relevance of light microscopy ideas to electron microscopy.

Unit-II:

Introduction, crystal geometry, lattice directions and planes, zone axis, interplaner spacing and angle, Stereographic projection, Bragg's condition of diffraction, X-ray scattering, application of X-ray diffraction – phase identification, estimation of grain size, particle size, residual stress.

Unit-III:

Principle, construction and operation of TEM, Interaction of electrons with specimen, reciprocal space and lattice, Ewald sphere, diffraction from finite crystal, preparation of specimens, bright and dark field imaging, selected area diffraction, indexing of diffraction patterns.

Unit-IV:

Construction and working principle of SEM. Resolving power, magnification, depth of field, depth of focus, image contrast, Secondary electron, back scattered mode of imaging and energy dispersive analysis of x-rays, Sample preparation techniques.

Unit-V:

Scanning Tunneling Microscopy (STM) & Atom Force Microscopy (AFM), Scanning Transmission electron Microscopy (STEM)

Unit-VI:

Principles of differential scanning calorimetry (DSC), differential thermal analysis (DTA), Dilatometry, Thermogravimetric analysis (TGA), Dynamic mechanical anaylsis, ThermoMechanical Anaylsis.

Learning resources

Text book:

1. P. J. Goodhew, J. Humphreys, R. Beanland, "Electron microscopy and analysis", CRC Press, 3rd edition, 2000.
2. B.D. Cullity, S.R. Stock, "Elements of X-Ray Diffraction", Pearson; 3 edition, 2001.

3. Brown, M.E., "Introduction to Thermal Analysis: Techniques and Applications", Springer-Verlag New York Inc.; 2nd edition, 2001

Reference Books:

1. P.J. Grundy and G.A. Jones, "Electron Microscopy in the Study of Materials", Hodder & Stoughton Educational, 1976.
2. D.B. Williams and C.B. Carter, "Transmission Electron Microscopy", Springer; 2nd edition, 2009.
3. C.S. Suryanarayana, and M. Grant Norton, "X-ray Diffraction: A Practical Approach",
4. Springer, 2013.
5. D.A. Skoog, F.J. Holler and S.R. Crouch, "Principles of Instrumental Analysis", Thomas Brookes/Cole, 6th Edition, 2007

Assessment Method

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MMM106	Science and Technology of Polymer	PEC	3-0-0	3

Course Content:

Unit-I :

Introduction to polymers and plastics**;** Conception of polymers, formation of polymers, types of polymers reactions such as addition and condensation, Mechanism of polymerization - Thermoplastic and Thermosetting materials methods of polymerization.

Unit-II:

Polymeric structure, raw materials and properties; Classification of polymers, raw materials for polymers and their sources. Brief study of structure of polymers and properties. Glass transition temperature and its significance. Crystallinity of polymeric materials, effect of time, temperature, catalysts and solvents on polymer properties, molecular weight of polymers.

Unit-III:

Compounding and fabrication of plastics, calendaring and casting. Recycling of Plastics, Functions of the following types of additives used in Polymers. 1. Fillers 2. Lubricants 3. Reinforcing agents 4. Plastricizers 5. Stabilizers 6. Antioxidants 7. Inhibitors 8. Promoters 9. Catalysts 10. Refarders 11. Limitators 12. Colorants 13. Cross-linking 14. Blowing agents 15. Photo degradiants 16. Bio-degradiants, laminated polymers.

Unit-IV:

Thermoplastics**;** Methods of addition polymerization, raw materials, manufacturing methods, properties and uses of the following ethenoid polymers; Polyethene (LDPE and HDPE), Polypropylene, Poly Vinyl Chloride, Polystyrene, Expanded polystyrene, Polytetra fluorethylene.

Unit-V:

Thermosetting resins; Introduction of thermosetting polymers, methods of condensation polymerizatin, raw materials, manufacturing method, properties and uses of Phenol- Formaldehyde resin, Urea-formaldehyde resins, alkyl resins.

Unit-VI:

Raw materials, manufacturing methods, properties and uses of the following plastics Acetals, Nylons, Polymethyl, Methocrylate (PMMA), Saturated polysters – PETP and PC, Cellulose acetate and viscose rayon. Introduction of natural rubbers and

synthetic rubbers like Buna-S, Buna-N, Thiokol, Polyurethane rubber and Silicon rubber.

Learning resources

Text book:

1. V.R. Gowariker, N.V. Viswanathan and Jayadev Sreedhar, “Polymer Science” New Age International (p) Ltd., New Delhi , 2010.
2. F.W. Bill Mayer, “Text book of polymer science” 3rd Edition – John Wiley & sons, Inc., New York, 2011.

Reference Books:

1. Raymond Seymour, "An Introduction to Polymer Chemistry", McGraw Hill, New York, 1971.
2. Charles A Harper, “Handbook of Plastics, Elastomers and Composites", McGraw Hill, USA, 1997.
3. McCrum N G, Buckley C P and Bucknall C B ,"Principles of Polymer Engineering", Oxford University Press, 1992.

Assessment Method

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MMM107	Powder Metallurgy	PEC	3-0-0	3

UNIT – I:

Historical background, steps in powder metallurgy, advantages of powder metallurgy process, advantages of powder metallurgy processing over conventional material processing, applications of powder metallurgy, limitations of powder metallurgy, recent trends; Powder production methods: Mechanical – milling, machining, other impaction techniques, mechanical alloying, Chemical – reduction, thermal decomposition, hydride-dehydride process, Physical methods – electrolytic deposition, gas atomization, water atomization, centrifugal atomization, other atomization approaches, atomization limitations.

UNIT – II:

Powder treatments – cleaning of powders, grinding, powder classification and screening, blending and mixing; coating of metal powders; Metal powder characteristics: sampling, metal powder characterization – chemical composition analysis, particle shape analysis, particle size, measurement techniques – microscopy, screening, sedimentation, light scattering, light blocking, x-ray techniques; microstructural features; packing and flow characteristics of powders – angle of repose, flow rate; density – apparent density, tap density; porosity; compressibility of metal powder; strength properties.

UNIT – III:

Powder pressing – powder shaping and compaction, binders; powder compaction methods – pressure less compaction techniques, pressure compaction techniques; classification of powder metallurgy parts; cold isostatic compaction – process, types, advantages, applications;.

UNIT – IV:

Powder rolling – steps involved, influence of powder characteristics on powder rolling, advantages, disadvantages, application; miscellaneous compaction techniques – continuous compaction, explosive compaction; High temperature compaction: principles of pressure sintering – uniaxial hot pressing, hot extrusion, spark sintering, hot isostatic pressing, injection moulding.

Unit-V

Types of sintering – solid state sintering, liquid phase sintering, activated sintering, reaction sintering, rate controlled sintering, microwave sintering, self-propagating high temperature synthesis, gas plasma sintering, spark plasma

sintering; sintering theory – thermodynamics of solid state sintering process, stages in solid state sintering, driving force for sintering, sintering mechanisms; variables – process variables, material variables; effects of sintering – dimensional changes, microstructural changes;

UNIT – VI

Sintering atmospheres – need for sintering atmosphere, functions of a sintering atmosphere, hydrogen, reformed hydrocarbon gases, nitrogen based mixtures, dissociated ammonia, inert gases, vacuum. **Post sintering operations**: introduction, sizing, coining, repressing, re-sintering, impregnation, Infiltration, heat treatment, steam treatment, machining, joining, plating, and other coatings. Powder metallurgy product: Porous Bearings, Porous Filters, Sintered Carbides, cermets.

Reference &Text Books:

1. Powder metallurgy science – **R M German**
2. Powder metallurgy science,technology & applications – **PC Angelo & RSubramanian**
3. Powder metallurgy- Science, Technology and Materials by **Anish Upadhyaya and G. S. Upadhyaya**

Video Reference: Manufacturing Processes-1: Source: NPTEL
Link: http://nptel.ac.in/courses/112107145/

Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MMM108	Nanomaterials – Synthesis and applications	PEC	3-0-0	3

Unit I:

Introduction to nanomaterials and nanostructures including both inorganic and organic materials, Top & Bottom up approaches, Challenges in Nanotechnology,Physical Chemistry of solid surfaces- Surface energy, Electrostatic-Van der Waals attraction potential, Interactions between two particles (DLVO theory), and Steric stabilization-Interactions between polymer layers, Mixed steric and electric interactions.

Unit II:

Homogeneous nucleation and subsequent growth, synthesis of oxide nanoparticles, Synthesis of metallic and semiconductor nanoparticles- Influences of reduction reagents, Influences of polymerstabilizer, Solgel, Hydrolysis, vapor phase reactions, **Solid** state phase segregation.

Unit III:

Fundamentals of heterogeneous nucleation, Heterogeneous nucleation and subsequent growth, Nanoparticles through Heterogeneous Nucleation, kinetically confined synthesis of nanoparticles –Aerosol synthesis, Spray paralysis, Template Based synthesis, and Growth termination processes.

Unit IV:

Spontaneous growth, Evaporation- Condensation growth, Dissolution- Condensation growth,
Vapor (or solution) – liquid – solid (VLS or SLS) growth,Template-Based Synthesis-Electrochemical deposition, Electrophoretic deposition,Template filling, Electrospinning, Lithography.

Unit V:

Fundamentals of Film Growth, Physical Vapor Deposition (PVD)-Evaporation, sputtering, the comparison between evaporation and sputtering, Chemical Vapor deposition (CVD) -

Typical chemical reactions, Reaction kinetics, CVD methods, Atomic Layer Deposition (ALD), Super lattices, self assembly, Electrochemical deposition, Solgel films.

Unit VI:

Molecular Electronics and Nanoelectronics, Nanobots, Biological Applications – Quantum Devices – Nanomechanics - Photonics- Nano structures as single electron transistor – principle and design, Photoelectrochemical Cells.

TEXT BOOKS

1. Guozhong Cao, "Nanostructures and Nanomaterials, synthesis, properties and applications", Imperial College Press, 2004.

2. Yury Gogotsi, "Nanomaterials – Handbook", CRC Press, Taylor & Francis group, 2006.

Assessment Method

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MMM109	Composite Materials	PEC	3-0-0	3

Course Content:

UNIT 1

Introduction to Composites, Matrices, Reinforcements, Classifications, Applications, Advantages, Fundamental concept of reinforcement, review of current developments; design fabrication and economic considerations;

UNIT 2

Basic mechanics of reinforcement, Stiffness of parallel arrays of fibres in a matrix. Discontinuous and particulate reinforcement. Fibres and resin materials. Rule of Mixtures, Critical Fiber Length, Short and Continuous Fibers, Fiber Orientation; Matrix and Reinforcement Materials, Polymeric Matrices, Metallic Matrices, Ceramic Matrices, Particulates, Flakes, Whiskers, Fibers: C, B, Glass, Aramid, Al2O3, SiC, Nature and manufacture of glass, carbon and aramid fibres.

UNIT 3

Review of the principal thermosetting and thermoplastic polymer matrix systems for composites. ; Polymer Matrix Composites (PMCs), Metal Matrix Composites (MMCs), Ceramic Matrix Composites (CMCs), CFRP & Carbon/Carbon Composites (CCCs);
Types, Manufacturing, Processing methods, Interfaces, Properties, Applications,

Toughening Mechanisms, Fiber Forms, Prepregs, Molding Compounds-Processes, LayUps, Filament Winding, Pultrusion, Recycling.

UNIT 4

Matrix –Reinforcement Interface, Wettability, Interactions at Interface, Interfacial Bonding Types, Interfacial Strength Tests, The role of the interface. The nature of fiber surfaces, wetting and adhesion

UNIT 5

Strength, Stiffness, Fracture, Toughness and toughening mechanisms of composites Strengths of unidirectional composites. Multiple fracture in laminates. Macroscopic fracture and energy dissipating processes. Application of fracture mechanics to composite materials.

UNIT 6

Fracture Mechanics and Fracture Toughness in Composites, Linear Elastic fracture mechanics, Toughness, Fiber matrix debonding, Fiber Pullout Buckling and PostBuckling; Failure criteria, Fatigue and Creep in composites, Environmental effects in Composites, Green composites; Synthesis and Properties of Nanocomposites.

Learning resources

Reference Books:

1. Chawla, Composite Materials: Science and Engineering, Springer, 2nd Ed. 1998.
2. Matthews & Rawlings, Composite Materials: Engineering and Science, Chapman & Hall, 1994.
3. Hull, An Introduction to Composite Materials, Cambridge, 2nd Edt. 1997.Bhat, S.V., Biomaterials, 2nd edition, Narosa Publishing, 2006

Assessment Method

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MMM111	Energy Storage Materials	PEC	3-0-0	3

Course Content

Unit-1

Introduction: Basics of solid state chemistry, defect structure of solids, surface and interface analysis.

Unit-2

Materials for energy storage: Fuel cells, different types, materials used, mechanism of operation, applications; Solar cells – introduction on photovoltaics, materials used, principle of operation, applications; Storage batteries – battery technology, assembly, electrochemical tests;

Unit-3

Supercapacitors – theory, high power super capacitor from carbon nanotubes; Hydrogen storage materials – mechanism of hydrogen storage.

Unit-4

Material Analysis: Thermal, structural and morphological analysis of the energy storage materials, different experimental techniques used.

Unit-5

Rechargable lithium ion battery: Intercalation compounds, anodes and composite anodes, cathode materials, polymeric electrolyte, currents trends of lithium ion batteries for consumer applications

Unit-6

Nanoscale materials: Nano crystalline materials, nanocomposites, nanotubes, energy storage capacity of the nanostructured materials. Magnetocaloric materials: Different types of materials, application of the magnetocaloric effect.

Learning resources

Text book:

1. Nazri G.A., Pistoia G., Lithium Batteries: Science and Technology, Kluwer Academic Publishers, 2004
2. Kumta P.K., Supercapacitors: Fundamentals, Systems, Applications, Emerging trends, Wiley-VCH Verlag, 2009

Reference Books:

1. Markvart T. and Castaner L., Solar cells: Materials, Manufacture and Application, Elsevier, 2003
2. Walker G., Solid State Hydrogen Storage: Materials and Chemistry, Woodhead Publishing, 2008
3. Tishin A.M. and Spichkin, Y.I., The Magnetocaloric Effect and its Applications, IOP publishing, 2003.

Assessment Method

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MMM201	Structure and Properties of Materials	PCC	3-0-0	3

Course Content:

UNIT 1

Structure of Solids: Bravais lattice and reciprocal lattice concept; Metallic, ionic and covalent solids; Crystal structures of NaCl, CsCl, Diamond cubic, Zinc Blende, Wurtzite, Rutile, Flourite, Fullerenes, Spinel, Perovskite etc., Non-crystalline Structures: General features and classification, Structure models for amorphous materials-microcrystalline chain and ring model, Molecular model. Structure and properties of metallic glass and amorphous semiconductors.

UNIT 2

Crystal Imperfections: Point imperfections, Burger vector, Dislocations (edge and screw) Properties of dislocation, Generation of dislocation, Partial dislocation, Stacking faults, Motion of dislocations (climb, cross-slip), Strain hardening and recovery, and Surface imperfections, Structure of high, Low angle and twin boundaries.

UNIT 3

Phase diagrams: Phase rule and phase diagrams, Unary and binary systems, Solid solutions, Hume Rothery rules, Intermediate phases and compounds, Isomorphous and eutectic systems, Lever rule, Various phase reactions, Introduction to different phase diagrams, Ternary system, Cooling curve and its use for drawing phase diagrams, Zone refining.

UNIT 4

Mechanical Behaviour of Materials: Elastic, inelastic viscoelastic properties, stressstrain relation. Failure of Materials: Brittle and ductile fracture, Creep failure,

Fatigue, Development of creep and fatigue resistant materials, Brittle failures in ceramics, Glasses and polymers.

UNIT 5

Thermal properties of materials: Heat capacity, Thermal expansion and thermal conductivity. Electrical properties of materials: Electronic and Ionic conduction; Energy Band structures in solids ; Electron Mobility ; Temperature variation of conductivity. Dielectric behaviour: Capacitance ; Types of polarization ; Frequency dependence of dielectric constant, Ferroelectricity and Piezoelectricity in materials. Magnetic properties: Diamagnetic; Ferromagnetic, anti-ferromagnetic and Ferrimagnetic behaviour of Materials, soft and hard magnetic materials, superconductivity.

UNIT 6

Optical properties: Light interaction with solids; Absorption, Transmission and Reflection, Luminescence; Photoconductivity, Lasers. Environmental Degradation of materials: Oxidation and Corrosion; Thermal and Photo Degradation, Chemical Degradation, Radiation Damage.

Learning resources

Reference Books:

1. V Raghavan – Materials Science & Engineering. – Prentice Hall of India Pvt. Ltd., New Delhi.
2. Murthy & Jena: Structure and properties of Engineering Materials, TMH New Delhi
3. W D Callister, Jr. – Materials Science & Engineering – An Introduction – John Willey & Sons, Inc, New York.
4. J F Shackelford – Introduction to Materials Science for Engineers – Maxwell Macmilan International Editions, Singapore.

Assessment Method

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MMM202	Mechanical Testing of Materials	PCC	3-1-0	3

Course Content:

UNIT I

Introduction: Strength of materials-Basic assumptions-elastic and plastic behaviour-Average stress and strain-concept of stress, strain and the types of stresses and strains. Dislocation theory: dislocation types, dislocation loop, dislocations in FCC, BCC and HCP, Stress fields and energies of dislocations forces on dislocations, forces between dislocation-Interaction of dislocations, dislocation multiplication, dislocation pileups, Interaction with points defects.

UNIT II

Fracture: Elementary theories of fracture, Griffith's theory of brittle fracture, Ductile Fracture,

Notch sensitivity. Hardness Test: Methods of hardness testing Brinells, Vickers, Rockwell, Rockwell superficial, Shore and Poldi methods, Microhardness test, relationship between hardness and other mechanical properties**.**

UNIT III

TENSION TESTING: ASTM Standards and specification, Engineering stress & strain, True stress strain curves, Holloman - Ludwig equation, Plastic Instability (Necking), Testing machines-types, testing procedures, properties measured, specimen dimensions, Problems. TORSION TESTING & SHEARING TEST: ASTM Standards and specification Testing Machines and procedures.

UNIT IV

Impact Test: Notched bar impact test and its significance, Charpy and Izod Tests, significance of transition temperature curve, Metallurgical factors affecting the transition temperature, temper embrittlement. DBTT curve and its importance. Fracture toughness testing - COD and CTOD tests.

UNIT V

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

UNIT VI

Creep and Stress Rupture: Introduction, The creep curve, Stress-rupture test, Structural changes during creep, Mechanism of creep deformation, theories of creep. Fracture at elevated temperature, Effect of Metallurgical variables on creep. Wear: Classification and mechanisms of wear, delamination theory, debris analysis, testing methods

Learning resources

Text book:

1. George E Dieter, “Mechanical Metallurgy", McGraw Hill Education, Third edition, 2017.
2. Thomas H.Courtney, “Mechanical Behaviour of Materials”, McGraw-Hilll, Boston, 2nd edition, 2000.

Reference Books:

1. Wullf et al, Vol. III “Mechanical Behavior of Materials", John Wiley and Sons, New York, 1983.
2. R.W. Hertzberg, "Deformation and Fracture Mechanics of Engineering Materials", John Wiley and Sons, 1976.
3. A .K. Bhargava, C. P. Sharma, “Mechanical behaviour and testing of materials”, PHI Learning, First edition, 2011.
4. Suryanarayana, A. V. K., “Testing of Metallic Materials”, Prentice Hall India, New Delhi, 1979
5. Marc A. Meyers, Krishan Kumar Chawla “Mechanical Behavior of Materials” Cambridge University Press, 2008

Assessment Method

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MMM203	**Non-Destructive Testing**	**PCC**	**3-0-0**	**3**

Course Content:

UNIT I

Scope and advantages of NDT, Comparison of NDT with DT. Classification of different NDT techniques. Visual Inspection Equipment used for visual inspection – Magnifying Glass Magnifying Mirror, Microscope Borescope, endoscopes or endoprobes Flexible Fiber Optic

Borescope, Video Imagescope. Role of NDT in quality control

UNIT II

Liquid penetration testing – Introduction, Principle, Equipment, Procedures. Characteristics of penetrants – developers – Evaluation. Hazards Precautions, advantages, limitations and Applications

UNIT III

Principle of Magnetic Particle Testing – different methods to generate magnetic fields. Magnetic Particle Testing Equipment – Magnetic Particle Testing Procedures Method of Demagnetizationmagnetic Particle Medium. Evaluation of Indications of Acceptance Standars – magnetic particle test – applications, advantages and limitations.

UNIT IV

Eddy Current Testing – Principles, equipment, advantages, and disadvantages. Factors Affecting Eddy Current Response-Material. Different types of the testing equipments. Conductivity Permeability – Frequency-Geometry-Proximity (Lift off). Typical Applications, limitations, Types of Probes.

UNIT V

X-ray radiography: its principles, equipment, advantages, limitations and applications. Radiographic

Procedure – Radiograph Interpretation, Radography Image Quality Indicators. Techiques – Film Processing-Methods of Viewing Radiographs. Radiographic Testing Procedures for welds. Precautions against radiation hazards.

UNIT VI

Introduction, Principle of operation Type of Ultrasonic Propagation- Ultrasonic probes**.** Types of Transducers – Ultrasonic Testing Techniques. Method for Evaluation Discontinuities-Ultrasonic Testing Procedures for different component – applications, advantages and limitations. Applications in inspection of castings, forgings, Extruded steel parts, bars, pipes, rails and dimensions measurement.

Learning resources

Text book:

1. "Non Destructive Evaluation and Quality Control", Metals Handbook, Vol. 17, 9th Ed., ASM, 1989 **Reference Books:**

1. Baldev Raj, Jayakumar T, Thavasimuthu M, Practical Non-Destructive Testing, 3rd Ed., Narosa, 2009
2. Srivastava, K.C., "Handbook of Magnetic Particle Testing", Oscar Publications, 1998

Assessment Method

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MM204	**Materials Characterization**	**PCC**	**3-1-0**	**4**

Course Content:

Unit-I :

Introduction, concept of resolution, Airy rings, numerical aperture, magnification, depth of field, depth of focus, lens defects and their corrections, principles of phase contrast – bright-field and dark-field contrast, polarized light microscopy, Quantitative microscopy, estimation of grain size, grain boundary area, relevance of light microscopy ideas to electron microscopy.

Unit-II:

Introduction, crystal geometry, lattice directions and planes, zone axis, interplaner spacing and angle, Stereographic projection, Bragg's condition of diffraction, X-ray scattering, application of X-ray diffraction – phase identification, estimation of grain size, particle size, residual stress.

Unit-III:

Principle, construction and operation of TEM, Interaction of electrons with specimen, reciprocal space and lattice, Ewald sphere, diffraction from finite crystal, preparation of specimens, bright and dark field imaging, selected area diffraction, indexing of diffraction patterns.

Unit-IV:

Construction and working principle of SEM. Resolving power, magnification, depth of field, depth of focus, image contrast, Secondary electron, back scattered mode of imaging and energy dispersive analysis of x-rays, Sample preparation techniques.

Unit-V:

Scanning Tunneling Microscopy (STM) & Atom Force Microscopy (AFM), Scanning Transmission electron Microscopy (STEM)

Unit-VI:

Principles of differential scanning calorimetry (DSC), differential thermal analysis (DTA), Dilatometry, Thermogravimetric analysis (TGA), Dynamic mechanical anaylsis, ThermoMechanical Anaylsis.

Learning resources

Text book:

1. P. J. Goodhew, J. Humphreys, R. Beanland, “Electron microscopy and analysis”, CRC Press, 3rd edition, 2000.
2. B.D. Cullity, S.R. Stock, “Elements of X-Ray Diffraction”, Pearson; 3 edition, 2001.
3. Brown, M.E., “Introduction to Thermal Analysis: Techniques and Applications”, Springer-Verlag New York Inc.; 2nd edition, 2001

Reference Books:

1. P.J. Grundy and G.A. Jones, “Electron Microscopy in the Study of Materials”, Hodder & Stoughton Educational, 1976.
2. D.B. Williams and C.B. Carter, “Transmission Electron Microscopy”, Springer; 2nd edition, 2009.
3. C.S. Suryanarayana, and M. Grant Norton, “X-ray Diffraction: A Practical Approach”,
4. Springer, 2013.
5. D.A. Skoog, F.J. Holler and S.R. Crouch, “Principles of Instrumental Analysis”, Thomas Brookes/Cole, 6th Edition, 2007

Assessment Method

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MMM205	**Materials Testing Laboratory -1**	**PCCL**	**0-0-3**	**1.5**

List of Experiments

1. Study of Metallurgical Microscope.
2. Metallographic preparation and microstructure evaluation of
   a. Low carbon steel, b. Medium carbon steel, c. High carbon steel
3. Metallographic preparation and microstructure evaluation of
   a. Aluminum, b. Aluminum alloy
4. Study of quantitative metallography and estimation of Grain size and Volume fraction.
5. Determination of the Brinell Hardness Values of Plain carbon steel and Aluminum alloy samples.

6. Determination of the Rockwell Hardness Values of Plain carbon steel and Aluminum alloy samples.
7. Determination of the Vickers Hardness Values of Plain carbon steel and Aluminum alloy samples.
8. Determination of Stress Strain Curve for AISI 1040 Steel and Identify elastic modulus, ultimate tensile strength, breaking stress, percentage elongation and percentage reduction in area.
9. Determination of Stress Strain Curve for Aluminum Alloy and Identify elastic modulus, ultimate tensile strength, breaking stress, percentage elongation and percentage reduction in area.
10. Determine the impact energy of given samples at different temperatures using Charpy impact tester and comment on the DBTT obtained.
11. Study of fatigue testing Machine and Determination of number of cycles to failure of a given material at a given stress.
12. Determination of creep behavior of lead at room temperature.
13. Determination of wear coefficient of given materials **Assessment Method**

Assessment Tool	Experiments	Record	Viva-Voce/ Quiz/MCQ/Lab project	Total
Weightage (%)	25%	5%	10%	40%
End Semester Examination weightage (%)				60%

Course Code	Course Name	Course Category	L-T-P	Credits
20MMM206	**Materials Testing Laboratory -2**	**PCCL**	**0-0-3**	**1.5**

List of Experiments

1. Dye penetrant inspection.
2. Magnetic Particle inspection.
3. Ultrasonic thickness measurement and flaw detection.
4. X-ray radiography (Film Interpretation).
5. Eddy current testing.
6. Determination of crystal structure by X-ray Diffraction (XRD)

7. Determination of lattice parameter by XRD
8. Determination of crystallite size by XRD
9. Fractography analysis using Scanning electron microscopy (SEM)
10. Determination of interlamellar spacing of pearlite using SEM
11. Chemical analysis using energy dispersive X-ray analysis in SEM (spot and line analysis).
12. Determination of corrosion rate by weight loss method 13. Determination of corrosion rate by electro-chemical method
14.

Assessment Method

Assessment Tool	Experiments	Record	Viva-Voce/ Quiz/MCQ/Lab project	Total
Weightage (%)	25%	5%	10%	40%
End Semester Examination weightage (%)				60%

Course Code	**Course Name**	**Course Category**	**L-T-P**	**Credits**
20MM207	**Advanced Characterization Techniques**	**PEC**	**3-0-0**	**3**

Course Content:

Unit-I :

Introduction:Relevance of advanced characterization to materials development, scientific understanding of phenomena in materials technology; Advanced Diffraction Techniques: Introduction; X-Ray, their production &properties Review of basic

diffraction, Various SAXS techniques and its applications in characterizing material SAXS GISAXS LEED and RHEED, EXAFS,SEXAFS/NEXAFS, Properties of neutron radiation; neutron sources; Small angle neutron scattering; Examples

Unit-II:

Advanced Surface Characterization Techniques: XPS,A ES & SIMS; Importance of surface characterization techniques; Physical principles of XPS, Photoelectric effects;

Unit-III:

Instrumentation, XPS patterns; Spin orbital Splitting; Quantitative analysis, Chemical effect, Chemical shift, XPS imaging Auger electron generation; Principle, Chemical effect, Quantitative analysis, Depth profiling, Applications, Static and Dynamic Secondary Ion Mass, Common modes of analysis, Depth Profiling, quantitative and Qualitative analysis, Comparison surface analysis techniques

Unit-IV:

Advanced Spectroscopic Techniques: Introduction; Electromagnetic spectroscopy; UVVisible Spectroscopy; Photo-luminescence spectroscopy; Infrared spectroscopy; Raman;
STEM; EELS

Unit-V:

Advanced Microscopic Techniques: Introduction; Electronmaterials interactions; TEM: HR, HAADF, STEM, In-situ TEM;

Unit-VI:

SEM, EBSD, In-situ SEM, AFM, STM, Laser Confocal Microscopy

Learning resources

1. Materials Characterization Techniques Sam Zhang, Lin Li, Ashok Kumar;CRC press,(2008)
2. Transmission Electron Microscopy; D.B. Williams and C.B. Carter,Plenum Press (2004)
3. Modern ESCAThe Principles and Practice of X-Ray Photoelectron Spectroscopy, Terry L.Barr, CRC press, (1994)
4. Scanning Electron Microscopy and X-ray Microanalysis by Joseph Goldstein, Dale E. Newbury, David C. Joy, and Charles E.;Springer Science (2003)
5. Advanced Techniques for Materials Characterization, Materials Science Foundations (monograph series) A.K. Tyagi, Mainak Roy,S.K.Kulshreshtha and S.Banerjee; Volumes 49 – 51 (2009)
6. Encyclopedia of Materials Characterisation Editors: c.r. Brundle, C.A.Evens, Jr,S. Wilson,Butterworth-Heinmann, Boston (1992)

Assessment Method

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MMXX04	**Electron Microscopy**	**PEC**	**3-0-0**	**3**

Course Content:

Unit-1

Human eye, optical microscope, transmission electron microscope (TEM), scanning electron microscope (SEM), scanning transmission electron microscope (STEM), analytical electron microscopes, scanning-probe microscopes

Unit-2

The electron gun, imaging system, theoretical limit, chromatic and spherical aberration, astigmatism, dept of field/focus, kinematics of scattering by atomic nuclei, electron-electron scattering, scattering contrast from amorphous and polycrystalline specimen, dark-field images, selected area diffraction technique, phase contrast, specimen preparation

Unit-3

Inelastic and elastic electron scattering, Kikuchi patterns, absorption and phase contrast, diffraction contrast, dynamical theory and solution for perfect crystal, grain boundary fringes, stacking fault fringes, Moiré fringes, dislocations, small loops, vacancy aggregates, precipitates

Unit-4

Operating principle, depth of field, noise, resolution, penetration of electrons into a solid, secondary-electron image, backscattered-electron image, other imaging modes, specimen preparation, environmental SEM, electron-beam lithography

Unit-5

The Bohr atom model, X-ray emission spectroscopy, X-ray energy-dispersive spectroscopy, quantitative analysis in the TEM and SEM,

Unit-6

X-ray wavelength-dispersive spectroscopy, auger electron spectroscopy (AES), electron energy-loss spectroscopy (EELS)

Learning resources

Reference Books:

1. Goodhew, P.J., Humphreys, J. and Beanland, R., “Electron Microscopy and Analysis”, 3rd Ed., Taylor and Francis,2000
2. Thomas, G., “Transmission Electron Microscopy of Materials”, Techbooks,1990
3. Reimer, L., “Scanning Electron Microscope: Physics of Image Formation and Microanalysis”, 2nd Ed., Springer,1998

4. Goldstein, J., Newbury, D.E., Joy, D.C., Lyman, C.E., Echlin P., Lifshin E., Sawyer L. and Michael, J.R., "Scanning Electron Microscopy and X-ray Microanalysis", 3rd Ed., Springer,2003
5. Carter, C.B. and Williams, D.B., "Transmission Electron Microscopy: A Textbook for Materials Science", 2nd Ed., Springer, 2009
6. Egerton, R., "Physical Principles of Electron Microscopy: An Introduction to TEM, SEM and AEM", Springer, 2010

Course Nature		**Theory**		
Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MM209	**Modern Instrumental methods of Analysis**	**PEC**	**3-0-0**	**3**

Course Content:

Unit-I :

Introduction to spectroscopic techniques. UV - Vis Spectrophotometry, Nephelometry, Turbidimetry, Reflectance Spectrometry, Fluorescence, Phosphorescence Spectrometry.

Unit-II:

Advanced Surface Characterization Techniques: XPS, AES & SIMS; Importance of surface characterization techniques; Physical principles of XPS, Photoelectric effects;

Unit-III:

Flame Emission and Atomic Absorption Spectrometry, Electrothermal AAS, Hydride generation AAS and Flameless mercury analysis. Infrared spectrometry.

Unit-IV:

Introduction to NMR spectroscopy and mass spectrometry.

Unit-V:

Electroanalytical techniques: Potentiometry, Voltametry, Polarography.

Unit-VI:

Chromatographic analysis: GC, LC, HPLC, Hyphenated techniques. Errors, statistical methods of data handling.

Learning resources

1. H.Willard , L.L Meritt, J.A Dean and F.A.Settle : Instrumental Methods of Analysis, 6th Edition, CBS.
2. A.I.Vogel: Quantitative Inorganic Analysis, 5th Edition, ELBS.
3. G.W. Ewing: Analytical Instrumentation Hand book, Marcell Dekker, NewYork, 1990.

Assessment Method

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MM210	**Metallurgical Failure Analysis**	**PEC**	**3-0-0**	**3**

Course Content:

Unit-I :

Stages of failure analysis, classification and identification of various types of fracture. Overview of fracture mechanics, characteristics of ductile and brittle fracture.

Unit-II:

General concepts, fracture characteristics revealed by microscopy, factors affecting fatigue life Creep, stress rupture, elevated temperature fatigue, metallurgical instabilities, environmental induced failure. Some case studies failures.

Unit-III:

Types of wear, analyzing wear failure. Corrosion failures- factors influencing corrosion failures, overview of various types of corrosion stress corrosion cracking, sources, characteristics of stress corrosion cracking. Procedure for analyzing stress corrosion cracking, various types of hydrogen damage failures.

Unit-IV:

Causes of failure in forging, failure of iron and steel castings, improper heat treatment, stress concentration and service conditions.

Unit-V:

Failure of weldments - reasons for failure procedure for weld failure analysis.

Unit-VI:

Reliability concept and hazard function, life prediction, condition monitoring, application of Poisson, exponential and Weibull distribution for reliability, bath tub curve, parallel and series system, mean time between failures and life testing.

Learning resources

1. ASM Metals Handbook “Failure Analysis and Prevention”, ASM Metals Park. Ohio, Vol.10, 10th Edition, 1995.
2. Colangelo.V.J. and Heiser.F.A., “Analysis of Metallurgical Failures”, John Wiley and Sons Inc. New York, USA, 1974.

Course Code	Course Name	Course Category	L-T-P	Credits
20MM4206	Fracture Mechanics	PEC	3-0-0	3

Course Content:

Unit – 1:

The geometry of stress and strain, elastic deformation, plastic and elasto-plastic deformation - limit analysis.

Unit – 2:

Two dimensional elastic fields – Analytical solutions yielding near a crack front – Irwin's approximation - plastic zone size – Dugdaale model – J integral and its relation to crack opening displacement

Unit – 3:

Griffith analysis – Linear Fracture Mechanics-Crack Opening displacement – Dynamic energy balance – crack arrest.

Unit – 4:

Empirical Relation describing crack growth by fatigue – Life calculations for a given load amplitude – effects of changing the load spectrum – Effects of Environment.

Unit – 5:

Examples of crack-growth Analysis for cyclic loading - leak before break – crack Initiation under large scale yielding – Thickness as a Design parameter – crack instability in Thermal or Residual – stress fields.

Unit – 6:

Fractographic analysis of ductile, brittle, fatigue and high temperature fractured surfaces. Failure Analysis: Steps involved in it. Case studies of some engineering failures.

Learning resources

Text Books:

1. Norman E. Dowling," Mechanical Behavior of Materials", 2nd Edition, Prentice-Hall 1999

Reference Books:

1. David Broek, "Elementary Engineering Fracture Mechanics", Fifthoff and Noerdhoff International Publisher, 1978.
2. Kare Hellan,"Introduction of Fracture Mechanics", McGraw-Hill Book Company,1985.
3. Preshant Kumar, "Elements of Fracture Mechanics", Wheeler Publishing, 1999.
4. Suresh, S.," Fatigue of Materials", Cambridge University Press, 2 nd edition, 1998.
5. Ashok Saxena," Nonlinear Fracture Mechanics for Engineers", CRC Press, 1998.
6. Schive, Jaap, "Fatigue of Structures and Materials", Kluwer Academic Publishers,2001.

Assessment Method

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits

20MMM213	**Creep and Fatigue Behavior of Materials**	**PEC**	**3-0-0**	**3**

Course Content:

Unit – 1

Strength of perfect crystal - Lattice resistance to dislocation movement – Elastic properties of dislocation – Dislocation multiplication – Slip and twinning in crystalline solid.

Unit-2 :

Creep of Solids – Temperature stress – Strain rate relation- Deformation mechanism – Super plasticity deformation mechanism maps – Extrapolation procedure for creep rupture data – materials for elevated temperature rules.

Unit-3 :

Macrofractrography fatigue failures - cyclic stress and strain controlled fatigue – Fatigue life estimation for notched components – Crack initiation mechanisms.

Unit-4 :

Stress and crack lengths correlations with FCP – Fracture modes in Fatigue – Microscopic fracture mechanisms – Crack growth behavior at Δk extremes – Influences – Micro structural aspects of FCP in metal alloys.

Unit 5 :

Typical defects – Microscopic surface examination – metallographic and fractographic examination

Unit-6 :

Component failure analysis – Fracture surface preservation – Cleaning and replication techniques and image interpretation.

Reference Books:

1. Richard. W. Hertzberg,“ Deformation and Fracture Mechanism of Engineering
2. Materials”, John Willey and Sons, 4th edition, 1996.
3. Anderson, T. L.,“ Fracture Mechanics: Fundamentals and Applications”, CRC Press, 2nd edition, 1995
4. Courtney, T. H.,“ Mechanical Behaviour of Materials”, McGraw-Hill, 1990
5. Jones, D. R. H,“ Engineering Materials 3, Materials Failure Analysis- Case Studies and Design Implications”, Pergamon, 1993.
6. Suresh, S.,“ Fatigue of Materials”, Cambridge University Press, 2 nd edition, 1998.
7. Cadek, J.,“ Creep in Metallic Materials”, Elsevier, 1988.

Assessment Tool	**Weekly tests**	**Monthly tests**	**End Semester Test**	**Total**
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MMM301	Introduction to Materials Science and Engineering	PCC	3-1-0	4

Course Content:

Unit – 1

CRYSTAL STRUCTURES: Review of atomic bonds-crystal systems and Bravais lattices, principal metallic crystal systems- BCC, FCC, HCP, atom positions and directions in cubic unit cells, miller indices for crystallographic planes in cubic unit cells, crystallographic planes and directions in hexagonal unit cells, volume, planar and linear atomic density calculations, allotropy, single crystal and polycrystalline materials, anisotropy, X-ray diffraction and determination of crystal structures, non-crystalline solids..

Unit-2

CRYSTALLINE IMPERFECTIONS: Types of point defects, vacancy dependence on temperature, solid solutions, formation of substitutional solid solutions and interstitial solid solutions, line defects-dislocations-edge, screw and mixed dislocations- Burger's vector-slip and twinning. Planar defects-grain boundaries, high angle and small angle grain boundaries, grain size determinations. volume defects. voids in BCC and FCC unit cells.

Unit-3

SOLIDIFICATION OF METALS: Homogeneous nucleation and Heterogeneous nucleation,
growth of crystals in liquid metals and formation of grain structure, grain structure in casting.

Unit-4

PHASE DIAGRAMS: Gibb's phase rule, binary isomorphous alloy systems, non-equilibrium cooling, binary eutectic system, eutectoid, peritectic and monotectic reaction, phase diagrams with intermediate phases and compounds, iron-carbon diagram ternary phase diagrams, development of microstructures.

Unit-5

FERROUS AND NON-FERROUS METALS: Effect of alloying additions on steel (Mn, Si, Cr, Mo, V, Ti & W)- classification of steels (tool steel, stainless)– cast irons – alloy cast irons- Copper and Copper alloys –Aluminum and its alloys- Magnesium and its alloys– Titanium and its alloys- Nickel and Cobalt alloys, properties and applications of these materials

Unit-6

NON-METALLIC AND NEWER MATERIALS: Types, properties and applications: Polymers, Ceramics and Composites– Super conductors, nanomaterials and their properties.

Reference Books:

1. Raghavan V, "Physical Metallurgy - Principles and Practice", PHI Learning Private Limited-New Delhi; 3rd edition, 2015.
2. William D. Callister, Jr., "Materials Science and Engineering an Introduction", John Wiley & Sons, Inc., 2nd Edition, 2007.
3. Donald R. Askeland, Pradeep P. Phule, "The Science and Engineering of Materials", Thomson Learning, 5th Edition, 2007.
4. Reza Abbaschian, Robert E. Reed-Hill, "Physical Metallurgy Principles", Cengage, 4th edition, 2013.
5. Sidney H. Avner, "Introduction to Physical Metallurgy", McGraw Hill Education; 2nd edition, 2017
6. Vijendra Singh, "Physical Metallurgy", Standard Publishers Distributors, New Delhi, 2012.

Assessment Tool	**Weekly tests**	**Monthly tests**	**End Semester Test**	**Total**
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MMM302	Heat Treatment and Surface Engineering	PCC	3-0-0	3

Course Content:

Unit – 1

IRON-CARBON EQUILIBRIUM DIAGRAM: Transformations on heating and cooling. Influence of alloying elements, TTT & CCT diagrams. General principles of heat treatment of steels

Unit-2

HEAT TREATMENT EQUIPMENT: Various heating media used for heat treatment, furnaces, temperature and atmosphere control.

Unit-3

HEAT TREATMENT PROCESSES: Annealing-types, Normalising, hardening & tempering, Hollomon Jaffe parameter, retained austenite - measurement and methods of its elimination, hardenability studies, Jominy end quench test, austempering and martempering.

thermo mechanical treatments. Precipitation hardening.

Unit-4

SURFACE MODIFICATION TECHNIQUES: Induction hardening, flame hardening, electron beam hardening and laser beam hardening. carburizing, nitriding, carbonitriding, cyaniding, boriding, CVD and PVD processes, ion implantation.

Unit-5

HEAT TREATMENT OF SPECIFIC ALLOYS: HSLA steels, high speed steels, maraging steels, tool steels and die steels. heat treatment of gray irons, white irons (malleabilising) and S.G.Irons. austempering of S.G.iron. heat treatment of aluminium copper alloys, aluminium magnesium silicon alloys, aluminium lithium alloys, copper beryllium alloys, copper nickel alloys, copper nickel tin alloys. Nickel aluminium alloys, titanium aluminium vanadium alloys.

Unit-6

DEFECTS: Defects in heat treated parts, causes and remedy design for heat treatment. SOFTWARES: Introduction to heat treatment softwares.

Reference Books:

1. Rajan and Sharma "Heat Treatment Principles and Techniques" - Prentice Hall of India, New Delhi, 2004.
2. Karl-Erik Thelning, "Steel and its Heat Treatment", Butterworths London, 1984.

Text Books:

1. American Society for Metals, "Metals Handbook Vol.4", ASM Metals Parks, USA, 2001.
2. Prabhudev K H, "Handbook of Heat Treatment of Steels", Tata McGraw Hill, New Delhi, 2000.
3. Vijendra Singh, “Heat Treatment of Metals", Standard Publishers, Delhi, 1998.
4. Balram Gupta, "Aerospace Materials", Vol.1, 2 and 3, S.Chand and Co., New Delhi, 1996.

Assessment Tool	**Weekly tests**	**Monthly tests**	**End Semester Test**	**Total**
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MMM303	Solidification Process and Casting	PCC	3-1-0	4

Course Content:

Unit-I :

Introduction: Foundry as a manufacturing centre, Scope and development of foundry, Types of foundries; Pattern: Types of patterns, Pattern materials, Pattern allowances, Pattern layout, Pattern making; Moulding and Core Making:Types of moulding equipment, Moulding materials, Moulding sands, Properties and selection of materials and additives used, Core and core making; Testing of Foundry Sand: Strength, Permeability, Moisture content, Shatter Index, Mouldability, Compactability, Loss on ignition, Clay content, AFS grain fineness number.

Unit-II :

Green sand moulding process, Dry sand moulding process, CO2 moulding process, No bake moulding process, Shell moulding process, Investment casting, Permanent moulding, Pressure die casting, Gravity die casting, Continuous casting, Electroslag casting, Squeeze casting, Slush casting, Thixocasting and rheocasting processes, Cosworth process, Magnetic moulding, Impulse moulding, High pressure moulding, Vacuum sealed moulding process.

Unit-III :

Thermodynamics of solidification: liquid phase, cooling curve analysis of pure metal and alloy, thermal undercooling, molar free energy; Kinetics of solidification: nucleation phenomena, homogeneous nucleation, heterogeneous nucleation, nucleating sites and agents, controlled nucleation, dynamic nucleation; Growth during solidification: structure of the Interface, normal growth, growth by surface nucleation, growth on imperfections; formation of planar, cellular, dendritic and equiaxed structures; Solidification of alloys: short range and long range solidifying alloys, constitutional undercooling, eutectic growth, factors influencing freezing and control

of alloy constituents; Solidification defects: segregation, shrinkage, porosity, hot tears, cold cracks.

Unit-IV :

Fluid dynamics: Fluidity, measurement of fluidity, effects of various parameters on fluidity, capillary flow, feeding mechanisms, centreline feeding resistance, principles of fluid flow; Gating: elements of gating system and their characteristics, aspiration of gases in gating system, filling time calculation, design of gating system, pouring basin, spure, sprue base well, runner, ingates; slag trap and filters, gating ratios

Unit-V :

Heat transport: solidification in sand mold, solidification in metal mold; Risering: risering practice, blind and atmospheric risers, riser size and location, risering curves, caine's method, NRL method and modulus methods, feeding distance, optimum risering practice, feeding aids, chills, padding.

Unit-VI :

Analysis of Casting defects: Surface defects, Discontinuity, Dimensional defects, Internal defects; **Learning resources**

Text book:

1. Peter Beelay, "Foundry Technology", Butterworth-Heinemann, 2001.
2. Ramana Rao T.V. "Metal Casting Principles and Practice", New Age International (P) Limited, 2003.
3. Jain.P.L. "Principles of Foundry Technology" Tata McGraw- Hill Publishing Co., Ltd, 1995.

Reference Books:

1. Flinn, R.A. "Fundamentals of Metal Casting", Addison – Wesley, 1963.
2. Srinivasan, N. K. "Foundry Technology" Khanna Publications, 2001.
3. Heine, R. W. Loper, C.R. and Rosenthal, P.C. "Principles of Metal Casting" Tata McGraw Hill Publishers, 2003.
    a. K Chakrabarti, "Casting Technology and Cast Alloys", PHI, 2008
4. K C John, "Metal Casting & Joining" PHI, 2015
5. P. C. Mukherjee, "Fundamentals of Metal casting Technology", Oxford IBH, 1980.

Assessment Method

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MMM304	Metal Joining Technology	PCC	3-0-0	3

Course Content:

Unit-I :

Scope of metal joining, Techniques of metal joining, Mechanisms for obtaining metallic continuity, Classification of welding processes; Arc Characteristics: Plasma, electron emission and ionization potential, arc temperature, influence of magnetic fieldson arcs, arc blow, metal transfer, effect of polarity, effect of gases, Power Sources: Power source characteristics, static and dynamic characteristics, CC and CV power source designs,current and voltage relationships, solid state power sources.

Unit-II:

Detailed description about the process equipment, control of parameters, consumable,specifications for electrodes and filler metals and applications related to the following processes: Shielded metal arc welding,gas metal arc welding, flux cored arc welding, gas tungsten arc welding, plasma arc welding, submerged arc welding, studarc welding.

Unit-III:

Principles, advantages disadvantages and fields ofapplication of the following welding processes:Oxy-fuel gas welding, Electro Slag Welding, Resistance welding, Electron BeamWelding, Laser beam Welding, thermit welding , solid state welding processes – friction welding, friction stir welding,explosive welding, ultrasonic welding, diffusion welding.

Unit-IV:

Thermal cycles in welding: Heat transfer in weldments, dissipation of welding heat, cooling rates, weld metal coolingcurves, peak temperature, calculating width of heat affected zones, solidification rate and effects of heat input; Development of residual

Stresses and distortion; Comparison of welding processes based on these considerations.

Unit-V:

Welding of structural steel, welding of cast iron, welding of stainless steel and other high-alloyed steels.Welding of copper and its alloys, welding of aluminum and its alloys, joining of dissimilar metals.

Unit-VI:

Welding defects, inspection and remedies - Mechanism, Techniques and scope of brazing, soldering and adhesive bonding processes.

Learning resources

Text book:

1. Parmer R.S., "Welding Engineering and Technology", 1stEdition, Khanna Publishers, New Delhi, 2008.
2. Robert and Messler, Principles of Welding (Processes, Physics, Chemistry and Metallurgy), Wiley InterscienceePublishers, 2008

Reference Books:

1. Lancaster, The Metallurgy of Welding, 6th Edition, William Andrew Publishing, NY, 2007
2. S Kou, Welding Metallurgy, John Wiley, USA, 2003
3. Welding Hand Book Vol. 5; 7th edition, AWS.

Assessment Method

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MMM305	Metal Forming	PCC	3-0-0	3

Course Content:

UNIT I

Stress and Strain Relationship for Elastic Behavior: Description of stress at a point. State of stress in two dimensions. Mohrs circle of stress in two dimensions, state of stress in three dimensions. Mohrs circle of stress in three dimensions. Description of strain at point.

UNIT II

Elements of Theory of Plasticity: The flow curve. True stress and true strain. Von-Mises distortion energy criterion, maximum shear stress or Tresca criterion. Octahedral shear stress and shear strain. Basics of the theories of plasticity.

UNIT III

Fundamentals of Metal Working: Classification of forming processes, Mechanics of metal working for slab method and uniform deformation energy method. Cold working, Recovery, recrystallization and grain growth, hot working, Strain-Rate effects, Work of plastic deformation.

UNIT IV

Forging: Classification of forging processes, forging equipment. Forging in plane strain. Opendie forging, closed-die forging, Forging of a cylinder in plane-strain. Forging defects. Rolling of Metals: Classification of rolling process, rolling mills. Hot rolling, cold rolling, rolling of bars and shapes, forging and geometrical relationships in rolling. Simplified analysis of rolling load, rolling variables, problems and defects in rolled products. Theories of hot rolling, torque and horsepower, theories of cold rolling, torque and horsepower.

UNIT V

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

UNIT VI

Drawing of Rods, Wires and Tubes: rod and wire drawing, tube drawing processes, deep drawing, residual stresses in rod, wire and tubes. SHEET METAL FORMING: Bending, wrap forming, spinning, stretch forming, deep drawing. Forming methods-rubber forming, shearing, blanking, bending, stretch forming, deep drawing, forming limit diagram, defects and application.

Learning resources

Text book:

1. Dieter G E, “Mechanical Metallurgy”, McGraw Hill Co., 2001.
2. Surender Kumar “Technology of metal forming processes” PHI Learning, 2008.

Reference Books:

1. W. F. Hosford and R. M. Caddell, “Metal Forming: Mechanics and Metallurgy”, Cambridge University Press, 2007
2. K. Lange, “Handbook of Metal Forming”, SME, 1985.
3. ASM “Metals Handbook, Vol. 14, Forming & Forging”, ASM, Metals Park, Ohio, USA, 1998.
4. P. N. Rao, “Manufacturing Technology - Vol.1” McGraw Hill Education; Fifth edition, 2018

Assessment Method

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MMM306	Powder Metallurgy	PEC	3-0-0	3

UNIT – I:

Historical background, steps in powder metallurgy, advantages of powder metallurgy process, advantages of powder metallurgy processing over conventional material processing, applications of powder metallurgy, limitations of powder metallurgy, recent trends; Powder production methods: Mechanical – milling, machining, other impaction techniques, mechanical alloying, Chemical – reduction, thermal decomposition, hydride-dehydride process, Physical methods – electrolytic deposition, gas atomization, water atomization, centrifugal atomization, other atomization approaches, atomization limitations.

UNIT – II:

Powder treatments – cleaning of powders, grinding, powder classification and screening, blending and mixing; coating of metal powders; Metal powder characteristics: sampling, metal powder characterization – chemical composition analysis, particle shape analysis, particle size, measurement techniques – microscopy, screening, sedimentation, light scattering, light blocking, x-ray techniques; microstructural features; packing and flow characteristics of powders – angle of repose, flow rate; density – apparent density, tap density; porosity; compressibility of metal powder; strength properties.

UNIT – III:

Powder pressing – powder shaping and compaction, binders; powder compaction methods – pressure less compaction techniques, pressure compaction techniques; classification of powder metallurgy parts; cold isostatic compaction – process, types, advantages, applications;.

UNIT – IV:

Powder rolling – steps involved, influence of powder characteristics on powder rolling, advantages, disadvantages, application; miscellaneous compaction techniques – continuous compaction, explosive compaction; High temperature compaction: principles of pressure sintering – uniaxial hot pressing, hot extrusion, spark sintering, hot isostatic pressing, injection moulding.

Unit-V

Types of sintering – solid state sintering, liquid phase sintering, activated sintering, reaction sintering, rate controlled sintering, microwave sintering, self-propagating high temperature synthesis, gas plasma sintering, spark plasma sintering; sintering theory – thermodynamics of solid state sintering process, stages in solid state sintering, driving force for sintering, sintering mechanisms;

variables – process variables, material variables; effects of sintering – dimensional changes, microstructural changes;

UNIT – VI

Sintering atmospheres – need for sintering atmosphere, functions of a sintering atmosphere, hydrogen, reformed hydrocarbon gases, nitrogen based mixtures, dissociated ammonia, inert gases, vacuum. **Post sintering operations**: introduction, sizing, coining, repressing, re-sintering, impregnation, Infiltration, heat treatment, steam treatment, machining, joining, plating, and other coatings. Powder metallurgy product: Porous Bearings, Porous Filters, Sintered Carbides, cermets.

Reference &Text Books:

1. Powder metallurgy science – R M German
2. Powder metallurgy science,technology & applications – PC Angelo & R Subramanian
3. Powder metallurgy- Science, Technology and Materials by Anish Upadhyaya and G. S. Upadhyaya

Video Reference: Manufacturing Processes-1: Source: NPTEL
Link: http://nptel.ac.in/courses/112107145/

Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MM401	Elements of Materials Science and Metallurgy	PCC	3-1-0	4

Course Content:

Unit-I

Review of atomic bonds; Atomic Arrangement in Materials: Concept of crystalline and amorphous solids, Space lattice and Unit cell, Crystal system and Bravais Lattices, Common crystal structure of metals, Crystallographic planes and directions, Voids in crystal structures; Allotropy.

Unit-II

Plastic deformation of pure metal: Mechanisms (slip& twin), critical resolved shear stress, single crystal tensile test (fcc), theoretical strength of ideal crystal. Crystal defects: Point defects, Line defects, Planer defects, Volume defects, Physical Properties of Materials: Thermal Properties, Electrical Properties, Magnetic Properties, Optical Properties.

Unit-III

Solid solution, definition and types of solid solution, Substitutional and Hume Rothery Rules, Intermetallic compounds, Normal valency compounds, Electron compounds, Interstitial compounds. Interaction of dislocation and solute atom. Definitions and basic concept phase diagram, Single component or Unary phase diagram, Binary Phase Diagrams: Isomorphous, Eutectic, Peritectic, Eutectoid, Monotectic & Syntectic reactions, Phase rule and Lever rule. Free energy and phase diagrams of ideal binary solutions. Common tangents to free energy curves.

Unit-IV

Detailed study of Fe-Fe_3C, Cu- Ni, Zn-Sn, Fe-C, Cu-Sn, Cu-Zn, Pb-Sn, Al-Si, Al-Cu phase diagrams. Nucleation, Homogeneous and Heterogeneous nucleation, Kinetics of nucleation, Growth and overall transformation kinetics, TTT and CCT diagrams.

Unit-V

Strengthening Mechanisms: Grain size strengthening-solid solution strengthening-factors affecting solid solution strengthening. martensitic strengthening, precipitation hardeningconditions for precipitation hardening-aging-formation of precipitates-coarsening of precipitates, mechanism of strengthening. dispersion strengthening-Introduction, factors

for effective dispersion hardening-strengthening mechanism-examples for above strengthening mechanisms-worked examples.

Unit-VI

Engineering Alloys: Ferrous alloys (stainless and special steels, cast irons), Non-ferrous alloys (Aluminum alloys, titanium alloys, copper base alloys). Metallography - Micro and Macro examinations, Principle and working of simple metallurgical microscope.

Learning resources

Text book:

1. Raghavan V, "Physical Metallurgy - Principles and Practice", PHI Learning Private Limited-New Delhi; 3rd edition, 2015.
2. William D. Callister, Jr., "Materials Science and Engineering an Introduction", John Wiley & Sons, Inc., 2nd Edition, 2007.
3. Donald R. Askeland, Pradeep P. Phule, "The Science and Engineering of Materials", Thomson Learning, 5th Edition, 2007.

Reference Books:

1. Reza Abbaschian, Robert E. Reed-Hill, "Physical Metallurgy Principles", Cengage, 4th edition, 2013.
2. Sidney H. Avner, "Introduction to Physical Metallurgy", McGraw Hill Education; 2nd edition, 2017
3. Vijendra Singh, "Physical Metallurgy", Standard Publishers Distributors, New Delhi, 2012.

Assessment Method

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MMM402	**Advanced Materials and Processes**	PEC	3-1-0	4

Course Content:

Unit – 1 :

Platonic solids, Quasicrystals, Symmetry of crystal structure (CTORHMT), Nano-crystalline Materials, Grain size variation from micron to nano size by several methods, Effect of grain boundaries, Phase solubility in nano crystalline state, Techniques to get nano crystalline state (Synthesis).

Unit – 2 :

Introduction, Zr-Ni system, Peak broadening effect, Solid state amoriphization, Amorphization criteria, Inherent grain stability, Factors affecting amorphization, Liquid state amorphization, Desiliconization, De-phosphorization, De-sulphurization.

Unit – 3 :

Introduction, Classification of quasicrystals, Effect of oxygen in quasicrystalline phase formation, Nano quasicrystals.

Unit – 4 :

Rapid solidification, Mechanical alloying, Emulsification droplet techniques, Advantages of extension of solid solubility. Ti-alloys, Shape memory alloys, Psuedo elasticity.

Unit – 5 : Introduction, Al-Si alloys, Al-Li alloys, Effect of the shape of precipitate, Nano composites of Al based alloys, Al-Ti alloy, Al-Ni alloys, Glass forming ability of Al-alloys.

Unit – 6 :

Strengthening mechanisms in pure metals, Effect of under cooling, strengthening mechanism in alloys, Ni-based, Fe-based & Co-based super alloys, Introduction to MMCs, In-situ composites, Advantages of In-situ processing and examples.

Learning resources

1. Video lectures by Dr.B.S.Murthy at https://www.youtube.com/watch?v=v1qwttBOdA&list=PL716BC63A7418B310.

Assessment Method				
Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MM403	**Advanced Ceramics and Glass**	**PCC**	**3-0-0**	**3**

Course Content:

Unit-I

Processing and evaluation of engineering ceramics. Fracture behaviour of ceramic materials, The Weibull distribution, Toughening mechanism.

Unit-II

Formation, mechanical properties and uses of fused alumina, sintered alumina products, borides, carbides, nitrites, silicides, zirconia and partially stabilized, zirconia, sialons.

Unit-III

Abrasives, abrasive operations, natural abrasives, abrasives like aluminium oxides, silicon carbide, diamond and boron nitride, miscellaneous synthetic abrasives, raw materials for abrasives, their proportioning, processing, manufacture of abrasives, grinding wheels, their drying, firing and testing.

Unit-IV

Glassy State; Kinetic and thermodynamic criteria for glass formation, use of Na2O-SiO2 and Na2OCaO- SiO2 phase diagrams in glass manufacture, types of glasses and their chemical compositions, Physical properties of glasses, density, refractive index, thermal expansion and thermal stresses, thermal endurance of glass, toughening of glasses, strength and fracture behaviour of glass and its articles, surface tension, viscosity and its measurement, effect of temperature and composition on the physical properties of glasses

Unit-V

Glass making raw materials, addition of cullet to the batch, reactions amongst the constituents of glass, thermal currents and flow pattern in the glass tank furnace, Defects in glass, bubbles and seeds, cords, stresses and colour inhomogeneity and their remedies, annealing of glasses.

Unit-VI

Glass ceramics; Nucleation and crystal growth in glasses, nucleation through micro miscibility, nucleating agents, properties and applications of glass-ceramics

Learning resources

Text book:

1. Ceramic Materials: Science and Engineering, C. Barry Carter, M. Grant Norton; Springer, 2nd ed. 2013.
2. Glass Science and Technology, D.R. Uhlmann, N. J. Kredl (ed); Vol. 1&2, Academic Press, 1990
3. Chemistry of Glasses, Amal Paul; Chapman Hall, 1990.

Reference Books:

1. Fundamentals of Ceramics, M.W Barsoum; McGraw Hill, 1997.
2. Introduction to Ceramics, 2nd Ed, W. David Kingery, H. K. Bowen, Donald R. Uhlmann,
   Wiley,1976.
3. Hank book of Glass Manufacture, F.V.Tooley; Vol 1&2, Ashlee Pub. Co, 1984.

Assessment Method

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MM404	Nanomaterials Synthesis and Processing	PCC	3-0-0	3

Course Content:

Unit-I

Processing and evaluation of engineering ceramics. Fracture behaviour of ceramic materials, The Weibull distribution, Toughening mechanism.

Unit-II

Formation, mechanical properties and uses of fused alumina, sintered alumina products, borides, carbides, nitrites, silicides, zirconia and partially stabilized, zirconia, sialons.

Unit-III

Abrasives, abrasive operations, natural abrasives, abrasives like aluminium oxides, silicon carbide, diamond and boron nitride, miscellaneous synthetic abrasives, raw materials for abrasives, their proportioning, processing, manufacture of abrasives, grinding wheels, their drying, firing and testing.

Unit-IV

Glassy State; Kinetic and thermodynamic criteria for glass formation, use of Na2O-SiO2 and Na2OCaO- SiO2 phase diagrams in glass manufacture, types of glasses and their chemical compositions, Physical properties of glasses, density, refractive index, thermal expansion and thermal stresses, thermal endurance of glass, toughening of glasses, strength and fracture behaviour of glass and its articles, surface tension, viscosity and its measurement, effect of temperature and composition on the physical properties of glasses

Unit-V

Glass making raw materials, addition of cullet to the batch, reactions amongst the constituents of glass, thermal currents and flow pattern in the glass tank furnace, Defects in glass, bubbles and seeds, cords, stresses and colour inhomogeneity and their remedies, annealing of glasses.

Unit-VI

Glass ceramics; Nucleation and crystal growth in glasses, nucleation through micro miscibility, nucleating agents, properties and applications of glass-ceramics

Learning resources

Text book:

4. Ceramic Materials: Science and Engineering, C. Barry Carter, M. Grant Norton; Springer, 2nd ed. 2013.
5. Glass Science and Technology, D.R. Uhlmann, N. J. Kredl (ed); Vol. 1&2, Academic Press, 1990
6. Chemistry of Glasses, Amal Paul; Chapman Hall, 1990.

Reference Books:

4. Fundamentals of Ceramics, M.W Barsoum; McGraw Hill, 1997.
5. Introduction to Ceramics, 2nd Ed, W. David Kingery, H. K. Bowen, Donald R. Uhlmann,
Wiley,1976.
6. Hank book of Glass Manufacture, F.V.Tooley; Vol 1&2, Ashlee Pub. Co, 1984.

Assessment Method

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MM405	Science and Technology of Composite Materials	PCC	3-0-0	3

Course Content:

UNIT 1

Introduction to Composites, Matrices, Reinforcements, Classifications, Applications, Advantages, Fundamental concept of reinforcement, review of current developments; design fabrication and economic considerations;

UNIT 2

Basic mechanics of reinforcement, Stiffness of parallel arrays of fibres in a matrix. Discontinuous and particulate reinforcement. Fibres and resin materials. Rule of Mixtures, Critical Fiber Length, Short and Continuous Fibers, Fiber Orientation; Matrix and Reinforcement Materials, Polymeric Matrices, Metallic Matrices, Ceramic Matrices, Particulates, Flakes, Whiskers, Fibers: C, B, Glass, Aramid, Al2O3, SiC, Nature and manufacture of glass, carbon and aramid fibres.

UNIT 3

Review of the principal thermosetting and thermoplastic polymer matrix systems for composites. ; Polymer Matrix Composites (PMCs), Metal Matrix Composites (MMCs), Ceramic Matrix Composites (CMCs), CFRP & Carbon/Carbon Composites (CCCs);
Types, Manufacturing, Processing methods, Interfaces, Properties, Applications, Toughening Mechanisms, Fiber Forms, Prepregs, Molding Compounds-Processes, LayUps, Filament Winding, Pultrusion, Recycling.

UNIT 4

Matrix –Reinforcement Interface, Wettability, Interactions at Interface, Interfacial Bonding Types, Interfacial Strength Tests, The role of the interface. The nature of fiber surfaces, wetting and adhesion

UNIT 5

Strength, Stiffness, Fracture, Toughness and toughening mechanisms of composites Strengths of unidirectional composites. Multiple fracture in laminates. Macroscopic fracture and energy dissipating processes. Application of fracture mechanics to composite materials.

UNIT 6

Fracture Mechanics and Fracture Toughness in Composites, Linear Elastic fracture mechanics, Toughness, Fiber matrix debonding, Fiber Pullout Buckling and PostBuckling; Failure criteria, Fatigue and Creep in composites, Environmental effects in Composites, Green composites; Synthesis and Properties of Nanocomposites.

Learning resources

Reference Books:

1. Chawla, Composite Materials: Science and Engineering, Springer, 2nd Ed. 1998.
2. Matthews & Rawlings, Composite Materials: Engineering and Science, Chapman & Hall, 1994.
3. Hull, An Introduction to Composite Materials, Cambridge, 2nd Edt. 1997.Bhat, S.V., Biomaterials, 2nd edition, Narosa Publishing, 2006

Assessment Method

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%

Course Code	Course Name	Course Category	L-T-P	Credits
20MM406	Processing of Semiconducting Materials	PCC	3-0-0	3

Course Content:

UNIT 1

Introduction to Electronic Materials, Electrical conductivity of materials, Direct & indirect band semiconductors, Semiconductor statisics.

UNIT 2

Doping in semiconductors- Diffusion, Ion implantation, Elemental and compound semiconductors, Crystal Growth: Bulk Silicon crystal growth Silicon float-zone GaAs crystal growth techniques

UNIT 3

Bandgap Engineering & Epitaxy, Low dimensional structures, CVD, MBE, Materials Characterization, Resistivity, Bandgap, Defects in materials

UNIT 4

Thin film deposition, Thermal oxidation, Dielectric deposition, Polysilicon deposition, Metallization

UNIT 5

Metal-semiconductor contact, Ohmic contact, Schottky contact, Applications, p-n junction

UNIT 6

Electrical properties of polymers, ceramics, dielectric and amorphous materials. Dielectric Materials and Insulation.

Learning resources

Reference Books:

1. S.M.Sze,"Semiconductor Devices:Physics & Technology", Wiley

2. S.O.Kasap,"Principles of Electronic Materials and Devices", Tata McGraw Hill.

Assessment Method

Assessment Tool	Weekly tests	Monthly tests	End Semester Test	Total
Weightage (%)	10%	30%	60%	100%