Course Scheme

(2020- 21 onwards)

Department

of

Metallurgical and Materials Engineering

CREDITS BREAK-UP FOR B.TECH. PROGRAMME (2020-21 onwards)

CURRICULAR COMPONENTS	Credits
(A) Institute Core Courses (ICC) a) Basic Sciences (BSC) b) Engineering Sciences (ESC) **c)** General Science (GSN)	 16 17 04
Total	**37**
(B) **Humanities, Communication and Management Elective Courses (HSSMEC)**	**12**
(C) Department Core Courses (DCC) (including 3 credits of Minor Project)	**39**
(D) Departmental Elective Courses (DEC)	**20**
(E) Institute Open Elective Courses (GSE/ HSEC) a) Courses b) Project (Compulsory Major Project)- Inter disciplinary	 **24** **06**
Total	**30**
(F)Internship/ Course Work* (4 credits of Deptt. Elective + 4 credits of Open Elective+ 4 credits of Project Work) *** Optional**	**12**
(G) Non Academic Courses (CCA)	**10**
Grand Total (For those who **do not opt** for Honours)	**160**
(H) Honours	**16**
Grand Total (For those who **opt** for degree with Honours)	**160 + 16**

Note: Minor Specialization will be given to a student who earns 16 credits from the basket of Open Elective courses offered by any one department (outside the parent department). Major Specialization will be given to a student who earns 16 credits in any one domain of Department Elective courses offered by parent department. To get Honours, the student will have to complete additional 16 credits of discipline Electives.

Semester wise UG Scheme to be implemented w.e.f. 2020-21 onwards

SEMESTER-I		
S.No.		**Credits**
1	Orientation (including Introduction to Discipline course-1 credit 14 hours)	2
2	BSC-I (Mathematics)	4
3	BSC-II/ BSC-IV (Physics/ Chemistry)	4
4	GSC-I & GSC-II/ ESC-I	4
5	HSM-I/ ESC-II	3
6	ESC-III/ ESC-IV	3 / 2
	TOTAL	**20 / 19**

SEMESTER-II		
S.No.		**Credits**
1	BSC-III (Mathematics)	4
2	BSC-IV/ BSC-II (Chemistry/ Physics)	4
3	ESC-I/ GSC-I & GSC-II	4
4	ESC-II/ HSM-I	3
5	ESC-IV/ ESC-III	2 / 3
6	ESC-V/ ESC-VI	2
	TOTAL	**19/ 20**

SEMESTER-III		
S.No.		**Credits**
1	ESC-VII/ HSM-II	3
2	Deptt Core Courses (DCC)	12
3	OE-I	4
4	Industrial Tour	2
	TOTAL	**21**

SEMESTER-IV		
S.No.		**Credits**
1	HSM-II/ ESC-VII	3
2	Deptt Core Courses (DCC)	12
3	OE-II	4
4	Proficiency-I	2
	TOTAL	**21**

SEMESTER-V		
S.No.		**Credits**
1	DEC-I	4
2	Deptt Core Courses (DCC)	12
3	DEC-II	4
4	Minor Project	3
	TOTAL	**23**

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

SEMESTER-VII		
S.No.		**Credits**
1	HSM-III	3
2	DEC-III	4
3	DEC-IV	4
4	OE-III	4
5	OE-IV	4
6	Major Project-I	2
	TOTAL	**21**

SEMESTER-VIII		
S.No.		**Credits**
1	HSM-IV	3
2	DEC-V	4
3	OE-V	4
4	OE-VI	4
5	Discipline	2
6	Proficiency-II	2
7	Major Project-II	4
	TOTAL	**23**

ABBREVIATIONS		
	Basic Science Course	BSC
	Engineering Science Course	ESC
	General Science Course	GSC
	Humanities, Social Sciences & Mgmt.	HSM

ABBREVIATIONS		
	Department Core Course	DCC
	Department Elective Course	DEC
	Open Elective Course	OE

Total Credits = 160 without Honours **Total Credits = 160 + 16 with Honours**

Note: Minor Specialization will be given to a student who earns 16 credits from the basket of Open Elective courses offered by any one department (outside the parent department). Major Specialization will be given to a student who earns 16 credits in any one domain of Department Elective courses offered by parent department. To get Honours, the student will have to complete additional 16 credits of discipline Electives.

ESC-I	Introduction to Computing
ESC-II	Engineering Drawing with CAD Software
ESC-III	Introduction to Mechatronics
ESC-IV	Introduction to Electronics & electrical Engineering
ESC-V	Introduction to Manufacturing
ESC-IV	Strength of Materials
ESC-VII	Artificial Intelligence

TEACHING SCHEME
FOR
B.Tech. (Metallurgical and Materials Engineering)
UG Scheme (2020- 21 onwards)

First Year

SEMESTER- I

Course Code	Course Name	L T P	Credit	
	Orientation **(including introduction to discipline course- 1 credit 14 hours)**		2	
MA 1101	Mathematics- I (Calculus and Ordinary Differential Equation		4	
CH 1101	Applied Chemistry- I		4	
ES 1101	Introduction to computing		4	
ES 1201	Engineering Drawing with CAD software		3	
ES 1401	Introduction to Electronics and Electrical Engineering		2	
	Total		**19**	

SEMESTER- II

Course Code	Course Name	L T P	Credit	
MA 1301	**Probability and Statistics**		4	
PY 1301	Condensed Matter Physics		4	
GS 1101 & GS 1201	Introduction to Environmental Science- I & Introduction to Environmental Science- II		4	
HSS 1101	Communication Skills and Ethics		3	
ES 1301	Introduction to Mechatronics		3	
ES 1601	**Strength of Materials**		2	
	Total		**20**	

Second Year

SEMESTER -I

Course Code	Course Name	L T P	Credit	
HS 2301/ HS 2302/ HS 2303/ HS 2304	Basics and Economics/ French/ General Psychology/ Sociology		3	ESC
MM 1211	Physical Metallurgy	3 0 2	4	**DCC**
MM 1212	Metallurgical Thermodynamics and Kinetics	3 1 0	4	**DCC**
MM 1213	Extractive Metallurgy for Non- Ferrous Metals	3 0 2	4	**DCC**
	OE-I		4	DEC
MM 7221	Industrial Tour		2	
	Total		**21**	

SEMESTER –II

Course Code	Course Name	L T P	Credit	
ES 1701	Artificial Intelligence		3	
MM 1221	Phase Transformation	3 1 0	4	**DCC**
MM 1222	Materials Characterization	2 0 2	3	**DCC**
MM 1223	Mechanical Behavior of Materials	3 1 0	4	**DCC**
MM 1224	Iron Making Technology	3 0 0	3	**DCC**
	OE-II		4	
	Proficiency-I		2	
	Total		**23**	

Third Year

SEMESTER –I

Course Code	Course Name	L T P	Credit	
MM 1311	Metal Casting Technology	3 0 2	4	**DCC**
MM 1312	Steel Making Technology	3 0 0	3	**DCC**
MM 1313	Mechanical Working of Metals	3 0 0	3	**DCC**
	DEC-I		4	
	DEC-II		4	**DEC- II**
MM 1314	Minor Project		3	
	Total		**21**	

SEMESTER –II

Course Code	Course Name	Credit	Category
Internship Training (Optional)		12	DCC
MM 1331	Internship –I (joint Evaluation by Industry mentor and Faculty Coordinator)	6	DCC
MM 1332	Internship –II (Report Writing and Viva Voce)	3	DCC
MM 1333	Internship –I (Presentation and Evaluation of Domain Knowledge)	3	DCC
or			
	DEC	4	DEC
	OE	4	OE
MM 1334	Project Work	4	
	Total	**12**	

Fourth Year

SEMESTER-I

Course Code	Subject	Credit	Category
	HSM-III	3	GSEC/MEC
	DEC-III	4	DEC
	DEC-IV	4	DEC
	OE-III	4	OE
	OE- IV	4	OE
MM 6441	Major Project-I	2	
	Total	**21**	

SEMESTER-II

Course Code	Subject	Credit	Category
	HSM-IV	3	
	DEC-V	4	DEC
	OE- V	4	OE
	OE- VI	4	OE
	Discipline	2	
	Proficiency- II	2	
MM 6451	Major Project- II	4	
	Total	**23**	

Department Core Courses (DCC)

Course Code	Course name	L T P	Credits
MM 1211	Physical Metallurgy	3 0 2	4
MM 1212	Metallurgical Thermodynamics and Kinetics	3 1 0	4
MM 1213	Extractive Metallurgy for Non-Ferrous Metals	3 0 2	4
MM 1221	Phase Transformation	3 1 0	4
MM 1222	Materials Characterization	2 0 2	3
MM 1223	Mechanical Behaviour of Materials	3 1 0	4
MM 1224	Iron Making Technology	3 0 0	3
MM 1311	Metal Casting Technology	3 0 2	4
MM 1312	Steel Making Technology	3 0 0	3
MM 1313	Mechanical Working of Metals	3 0 0	3

Department Elective Courses (DEC)

Course Code	Course name	L T P	Credits
MM 2201	Welding Technology	2 0 0	2
MM 2202	Additive Manufacturing		
MM 2203	Polymer Technology		
MM 2204	Materials Handling		
MM 2205	Ceramics for Strategic Applications		
MM 2206	Composite Materials and Mechanics		
MM 2207	Industrial Tribology		
MM 2208	Science and Technology of Sintering		
MM 2209	Thin Film Technology		
MM 2210	Nano Materials for Optoelectronics Applications		
MM 2211	Nano Materials for Magnetic Applications		
MM 2212	Powder Metallurgy		
MM 2213	Fundamentals of Electrochemistry		
MM 2214	Electrochemical processes for Industrials Applications		
MM 2215	Spectroscopy and XRD		
MM 2216	High Temperature Corrosion		
MM 2401	Nondestructive Testing Techniques	3 1 0	4
MM 2402	Materials Joining Techniques	3 1 0	
MM 2403	High Entropy Alloys	3 1 0	
MM 2404	Advanced Engineering Materials	3 1 0	
MM 2405	Emerging Materials for Energy Harvesting	3 1 0	
MM 2406	Non-Conventional Energy Resources	3 1 0	
MM 2407	Solar Energy Engineering and Technology	3 1 0	
MM 2408	Failure Analysis of Metals and Alloys	3 0 2	
MM 2409	Degradation of Materials	3 0 2	
MM 2410	Heat Treatment of Steels	3 0 2	
MM 2411	Modelling and Simulation in Metallurgy	3 0 2	

Open Elective Course (OE)

Course Code	Course name	L T P	Credits
MM 6001	Surface Engineering	3 1 0	4
MM 6002	Failure Analysis of Metals and Alloys	3 0 2	
MM 6003	Materials Science and Engineering	3 1 0	
MM 6004	Materials Characterization Techniques	3 0 2	
MM 6005	Heat Treatment of Steels	3 0 2	
MM 6006	Nanomaterials Technology and Applications	3 1 0	
MM 6007	Energy Storage Materials	3 0 2	
MM 6008	Biomaterials	3 0 2	
MM 6009	Metal Casting	3 0 2	
MM 6010	Mechanical Behaviour of Materials	3 1 0	

Minor Specialization Courses

Course Code	Course name	L T P	Credits
Any four courses (total 16 credits) for the students from other departments			
MM 5001/ MM 6003	Materials Science and Engineering	3 1 0	4
MM 5002/ MM 6004	Materials Characterization Techniques	3 0 2	
MM 5003/ MM 6005	Heat Treatment of steels	3 0 2	
MM 5004/ MM 6007	Energy Storage Materials	3 0 2	
MM 5005/ MM 6008	Biomaterials	3 0 2	
MM 5006/ MM 6010	Mechanical Behaviour of Materials	3 1 0	

Honours Courses

Course Code	Course name	L T P	Credits
Any four courses (total 16 credits) for the students of parent department.			
MM 3001/ MM 6001	Surface Engineering	3 1 0	4
MM 3002/ MM 6002	Failure Analysis of Metals and Alloys	3 0 2	
MM 3003/ MM 6005	Heat Treatment of Steels	3 0 2	
MM 3004/ MM 6006	Nanomaterials Technology and Applications	3 1 0	
MM 3005/ MM 6007	Energy Storage Materials	3 0 2	
MM 3006/ MM 6008	Biomaterials	3 0 2	

Major Specialization Courses
(Advanced Material Applications)

Course Code	Course name	L T P	Credits
MM 4001/ MM 2403	High Entropy Alloys*	3 1 0	4
MM 4002/ MM 2405	Emerging Materials for Energy Harvesting*	3 0 2	
MM 4003/ MM 2406	Non-Conventional Energy Resources	3 1 0	
MM 4004/ MM 2407	Solar Energy Engineering and Technology	3 1 0	
MM 4005/ MM 2409	Degradation of Materials	3 0 2	
MM 4006/ MM 2411	Modelling and Simulation in Metallurgy	3 0 2	

*compulsory Courses of 8 credits out of total 16 credits.

Orientation Course (OR1101) of 2 credits includes Introduction to Discipline Engineering of 1 credit – 14 hours

Course Name	**:**	**Introduction to Metallurgical & Materials Engineering**
Course Code	**:**	
Credits	**:**	**1**
LTP	**:**	**1-0-0**

Course Objectives:

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

1. Understand and classify the sub branches and domains of Materials & Metallurgical Engineering stream.
2. The possible opportunities in the domains of Materials & Metallurgical Engineering.
3. Understand all basic principles involved in the theory of Elasticity and Plasticity.

Total No. of Lectures– 14

Lecture wise breakup		**Number of Lectures**
1	**History and Evolution** Definition, concept, scope and nature of materials and metallurgy industries associated to metallurgical engineering and allied fields, opportunities in metallurgical and materials engineering	2
2	**Basics of Material Development** Principles of production of ferrous and non-ferrous metals; overview of alloy making and Units involved in such process.	3
3	**Overview of Materials Processing Technologies** Principle and overview of heat treatment industry, metal casting units, material joining technology etc.	3
4	**Basics of Materials Selection** Basics and principles involved in material selection for special applications like high temperature exposure, nuclear reactor materials; corrosion resistant materials etc	3
5	**Special and New Materials** Introduction to newer materials such as smart materials, biomaterials and their applications.	3

Course Outcomes:

Student will be able to:

1. The student will be able to understand and create the areas and domains in Metallurgical & Materials Engineering on the basis of his/her interest and opportunity available in present industrial scenario.
2. The student will be able to understand the basic principles of selection of materials and challenges to entrepreneurs in metallurgy

Suggested Books

Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1.	Introduction to Physical Metallurgy/ S.H.Avner/ McGrawHill/	2017
2	Materials Science and Engineering/ V.Raghavan/ PrenticeHall,NewDelhi	2015
3	Fundamentals of Materials Science and Engineering/WDCallisterJr./ JohnWileyandsons/ 9thEdition.	2014
4.	Principle of Blas Furnace (Iron making)/ AK Biswas/ Cootha	2003

Course Name	**:**	**Calculus and Ordinary Differential Equations**
Course Code	**:**	**MA1101 (Common to all branches)**
Credits	**:**	**4**
L T P	**:**	**3-1-0**
Total No. of Lectures	**:**	**42**

Course Objectives:
At the end of the semester, the students should be able to

1	understand the behavior of infinite series and their use.
2	learn the concepts related to differential calculus of functions of several variables and their applications.
3	learn the concept and methods of evaluating multiple integrals and their applications to various problems.
4	learn the methods to solve ordinary differential equations of various types.

	Lecture wise breakup	**No. of Lectures**
1	**INFINITE SERIES** Infinite series and convergence, alternating series, power series and convergence. Taylor's and Maclaurin's Series. (Scope as in Chapter 8, Sections 8.1, 8.3 – 8.9 of Text Book1).	8
2	**DIFFERENTIAL CALCULUS** Limit, Continuity and Partial Derivatives; Euler's Theoem for Homogeneous functions; Differentiability, Linearization and Differentials; Chain rule; Extreme values and Saddle Points; Lagrange multipliers; Taylor's Formula**. (**Scope as in Chapter 12, Sections 12.1 – 12.6, 12.8 – 12.10 of Text Book 1).	12
3	**INTEGRAL CALCULUS** Cylinders and Quadric surfaces, Double integrals in Rectangular and Polar form, Triple integrals in Rectangular, Cylindrical and Spherical Coordinates, Substitutions in Multiple integrals. Applications to practical problems. (Scope as in Chapter10, Sections10.6 and 10.7 and Chapter 13, Sections 13.1, 13.3, 13.4,13.6 and 13.7 of Text Book 1).	10
4	**ORDINARY DIFFERENTIAL EQUATIONS** First order exact differential equations, Integrating factor, Orthogonal trajectories, Second and Higher order Linear Differential Equations with constant coefficients, Differential Operators, Methods of Variation of Parameters and Undetermined Coefficients, Euler Cauchy Equation, Wronskian. (Scope as in Chapter 1, Section 1.5, 1.8 Chapter 2, 2.1-2.4, 2.6, 2.9-2.10, 2.13- 2.15 of Text Book 2).	12

Course Outcomes:
At the end of the semester, the students are able to

1	test the behavior of infinite series.
2	Apply the concepts of differential calculus of functions of several variables.
3	evaluate multiple integrals and apply them to practical problems.
4	solve ordinary differential equations of various types

Text Books:

1	Calculus and Analytic Geometry, Thomas and Finney, 9th edition, Pearson Education Asia.	2006
2	Advanced Engineering Mathematics, Kreyszig, 8th edition, John Wiley and Sons.	2005

Reference Books:

1	Differential Equations, Frank Ayers, SI edition, Mc Graw Hill.	1972
2	Advanced Engineering Mathematics, Wylie and Barrett, 6th edition, Mc Graw Hill.	2003

Course Name	**:**	**Probability and Statistics**
Course Code	**:**	**MA1301 (For CSE, Electrical, MMED, Prod and student-specific for Civil)**
Credits	**:**	**4**
L T P	**:**	**3-1-0**
Total No. of Lectures	**:**	**42**

Course Objectives:
At the end of the semester, the students should be able to

1	understand the concepts of random variable and probability distribution.
2	learn the concepts of some theoretical probability distributions
3	understand the concept of sampling distribution and be able to construct and interpret confidence interval estimates for the mean, proportion , difference of mean and proportion
4	learn to use various tests of hypotheses

	Lecture wise breakup	**No. of Lectures**
1	**RANDOM VARIABLES** Random variables, Discrete, Continuous and Joint Probability distributions, Marginal and Conditional distributions, Independent random variables, Expectation, Variance and Covariance, Means and variances of linear combinations of random variables, Chebyshev's inequality	10
2	**PROBABILITY DISTRIBUTIONS** Binomial, Poisson, Uniform and Normal distributions, Normal and Poisson approximations to Binomial, Moments, Moment generating function.	10
3	**SAMPLING DISTRIBUTIONS** Population, Sample, Sampling distributions, Central limit theorem, Distribution of sample mean, Difference of means, Proportions and difference of proportions, Chi-square distribution, Student's t-distribution.	7
4	**ESTIMATION** Estimation of parameters, Point estimate, Confidence interval for mean, difference of means and proportions.	6
5	**TESTS OF HYPOTHESES** Hypothesis, Test statistic, Critical region, Significance level, Single Sample and Two Samples Tests for mean and proportion.	9

Course Outcomes:
At the end of the semester, the students are able to

1	understand the concepts of random variable and probability distribution.
2	apply the concepts of some theoretical probability distributions .
3	use the concept of sampling distribution and apply tests of significance to practical problems of engineering
4	apply various tests of hypotheses

Text Books:

1	Probability and statistics for Engineers and Scientists, Walpole, Myers, Myers and Ye, 7th edition, Pearson Education	2006

Reference Books:

1	Miller and Freund's: Probability and Statistics for Engineers, Richard A. Johnson, C.B. Gupta, Pearson Education.	2006
2	John E. Freund's: Mathematical statistics with Application, Miller and Miller, Pearson Education.	2004

Course Name	**:**	**Condensed Matter Physics**
Course Code	**:**	**PY1301 (For Metallurgical Engineering)**
Credits	**:**	**4**
L T P	**:**	**3-0-2**

Course Objectives:	
1	To familiarize the students with basic concepts of the condensed phase of matter especially solids.
2	Tomake the students able to understand the crystal structure, lattice vibrations, electronic properties, dielectric and the magnetic properties etc. in relation to engineering applications.
3	To familiarize students with the concept of Density Functional Theory.
4	To make the students able to understand the basics concepts of superconductivity, nanoscience and their applications.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**Basic concept of electrons and phonons:** Space lattice, crystal structures (cubic and hexagonal cells). Lattice vibrations: Introduction of Phonons, Vibrations of one dimensional monoatomic and diatomic lattices, Momentum of Phonons.	(5)
2	**Basic of Free Electron Theory**; Classical and Quantum Theory of free electrons,Fermi-Dirac Distribution Function, Density of States, Motion in magnetic field (Hall effect), Electron in a Periodic Potential (Kronig Penney Model), Energy versus wave vector, Energy bands in solids.	(10)
3	**Basic of electronic interactions, Dynamics and Responses:** Electron dynamics in crystals, Schrodinger Equation, Born Oppenheimer Approximation, HartreeFock Approximation, Hohenberg and Kohn formulation of DFT, Kohn Sham formulation of DFT, Applications of Density Functional Theory.	(7)
4	**Dielectrics and Magnetism:** Fundamental of dielectrics, active and passive dielectrics, various polarization mechanisms, Frequency and temperature dependence on polarization of dielectrics, Internal field, Dielectric Loss Tangent, Dielectric Breakdown. Fundamentals of Magnetism, Classification of magnetic materials, ferromagnetic domains, hysteresis, antiferromagnetism.	(8)
5	**Optical Phenomena and Superconductivity**: Basic concept, Electronic transitions and optical properties of metals and non-metals, Optical phenomena: luminescence, lasers, thermal emission, photo-conductivity (only Definitions). Superconductivity: Introduction, Effect of Magnetic field, Effect of current, Type1 and Type II superconductors, Thermal properties, Isotope effect, London Equations, Qualitative idea of BCS theory, Applications of superconductivity.	(8)
6	**Nanoscience:** Introduction, Length Scale, Size dependence of properties: Surface energy, Electronic structure, Reactivity, Optical Properties, Melting Point, Nanoclusters, Nanocomposite, Fullerenes, Carbon Nanotubes and Graphene.	(4)

S.No.	**List of Experiments**	**Number of Turns**
1	Familiarization of basic instruments Vernier Calipers, Screw Gauge and Spectrometer.	1
2	To study dielectric constant and Curie temperature of Ferroelectric ceramic BaTiO3.	1
3	To study the ratio of electron charge to mass ratio in uniform magnetic field.	1
4	To determine coercivity of magnetic material using hysteresis loop tracer.	1
5	To study the Hall effect and to determine Hall Voltage (V_H) and Hall coefficient (R_H)	1
6	To determine the energy band gap of semiconductor (Ge) using Four Probe Method.	1
7	To study the variation of magnetic field with distance along the axis of current carrying circular coil using Stewart and Gee's apparatus.	1
8	To Plot I-V Characteristics of Solar cell.	1
9	(i) To determine the wavelength of He-Ne laser using transmission grating. (ii) To determine the slit width using the diffraction pattern.	1
10	To determine magnetic susceptibility of paramagnetic sample using Quink's tube method.	1
11	To determine the flashing and Quenching Potential of neon/Argon and also to find the capacitance of unknown capacitor.	1

Course Outcomes: By the end of the course	
1	Students will be able to understand the physics behind structural properties of the solids.
2	Students will be able to develop their capability to tackle problems in general and in various areas covered in the condensed matter physics.
3	Students will be aware of latest developments in certain areas of condensed matter physics, which have important applications for societal needs.

Suggested Books:	
Sr. No	**Name of Book/ Authors/ Publisher**
1	Introduction to Solid State Physics, Charles Kittel, Wiley India Pvt. Ltd., New Delhi (8^{th} Edition)
2	Solid State Physics, S.O. Pillai, New Age International, Pvt. Ltd., New Delhi (5^{th} Edition)
3	Solid State Physics, M. A. Wahab, Narosa Publishing House, Pvt. Ltd. New Delhi (3^{rd} Edition).
4.	Fundamentals of Condensed Matter Physics, Marvin L. Cohen and Steven G. Louie, Cambridge University Press (June 2017).
5.	Solid State Physics R.K. Puri, V.K. Babbar, S. Chand & Company, Pvt. Ltd. New Delhi (3^{rd} Edition).
6.	Density Functional Theory: A Practical Introduction, David S. Sholl Janice A. Steckel, John Wiley &Sons, Inc., Hoboken, New Jersey.

Course Name	**:**	**Applied Chemistry I**
Course Code	**:**	**CH1101 (For Electrical, ECE and CSE)**
Credits	**:**	**4**
L T P	**:**	**3 -0-2**

Objective: To teach the fundamentals and application of chemical sciences essential for the development of electrical and electronic materials and technologies. Students will be learning various analytical techniques for the characterizations of electronic organic/inorganic materials.

Total No. of Lecture-42

	Lecture wise breakup	**Number of Lectures**
1	**Fundamentals for Applied Chemistry** Molecular orbital theory, Jahn-Teller Effect in Crystal Field Theory, Solid state chemistry: Crystal defects and line imperfections, Reaction mechanism in organic chemistry: Principles and methods of determination, Chemical Kinetics: Langmuir–Hinselwood Mechanism, acid-base equilibria in non aqueous media, Introduction to Computational chemistry and open source softwares	**(10)**
3	**Polymeric Materials** Mechanism and methods of polymerization, structure-activity relationship, Conducting Polymers: types (n- or p- doping) and applications, Polymeric fibre materials	**(6)**
4	**Energy Storage and Sensing Devices:** Fundamentals of Electrochemistry, types of electrodes, Reference electrodes, Ion-selective electrodes, Fuel cells, Batteries (Lithium-ion Batteries and EV Batteries), Renewable energy (Artificial photosynthesis), Solar cells, Sensors for IoT	**(8)**
5	**Spectroscopic Methods for structural Analysis:** Principle and applications (UV, IR, NMR, SEM and TEM)	**(9)**
6	**Chemistry of Electronic and Electrical Materials** Semi-conductor and super conducting Materials, Carbon materials, Optical Materials (OLED), 2D Materials, Magnetic materials.	**(9)**

Practical	
Sr. No.	**Name of Experiment**
1.	Synthesis of metal-complex and determination of melting point
2.	Implementation of IR technique for the analysis of metal-complex synthesized
3.	Preparation of Metal-oxide by sol gel and hydrothermal method
4.	Characterization of metal–oxide using SEM technique by structural determination
5	Synthesis of an organic compound and chemicals analysis.
6	Structural analysis of organic compound by NMR technique.
7	Synthesis of polymer material and its analysis.
8	Application of UV spectroscopy for polymer functional group analysis
9	Investigation of redox chemistry of an inorganic material by Cyclic Voltammeter.
10	Application of open source software for chemical analysis and drug design.

Outcomes:

1	To be able to apply the fundamentals of chemistry towards developing new Technologies based on new materials.
2	To attain the essential analytical skills and designing of materials for electrical and electronic applications.
3	Application of software as important tools in technological applications.

Books:

1	Concise Inorganic Chemistry, by J. D. Lee, 5th Edition, 2003 (Chapman & Hall).
2	Organic Chemistry by S. M. Mukherji, and S. P. Singh, 2017 (Newagepublishers).
3	Principles of Physical Chemistry by Puri, Sharma and Pathania, 2008 (W.H. Freeman & Co).
4	Atkin's Physical Chemistry by Peter Atkins, Julio de Paula, 7th Edition (Oxford University Press).
5	Principle of Polymerization by G. Odian, 4th Edition, (John Wiley & Sons, Inc.).
6	D. S. Pavia, G.M. Lasmpman and G.S. Kriz: Introduction to Spectroscopy, 4th Edition, (Thomson learning, Indian Edition).
7	Computational chemistry: Introduction to theory and applications of molecular and quantum mechanics: Lewars Errol G. (Springer)
8	NPTEL web lectures: Chemistry of Materials, Engineering Chemistry I & III.

Course Name	**:**	**Applied Chemistry II**
Course Code	**:**	**CH1201 (For Mech., Prod., MMED, Aero. And Civil)**
Credits	**:**	**4**
L T P	**:**	**3 -0-2**

Total No. of Lecture-42

Objective: To teach the fundamentals and application of chemical sciences essential for the development of engineering materials and processing technologies. Students will be learning various analytical techniques for the characterizations of composites and hybrid materials.

	Lecture wise breakup	**No. of Lectures**
1	**Fundamentals for Applied Chemistry** Molecular orbital theory, Jahn-Teller Effect in Crystal Field Theory, Solid state chemistry: Crystal defects and line imperfections, Reaction mechanism in organic chemistry: Principles and methods of determination, Chemical Kinetics: Langmuir –Hinselwood Mechanism, Acid -base equilibria in non aqueous media	**(8)**
2	**Polymer Chemistry** Mechanism and methods of polymerization, Structure-Activity relationship, High performance polymers and applications, Natural and synthetic fibres, biodegradable polymers	**(5)**
3	**Fuels and Catalysis** Petroleum processing**,** Solid and liquid Fuels for Propellents, Chemistry of combustion and equations, Catalytic convertors	**(5)**
4	**Electrochemistry and Corrosion:** Introduction to Electrochemistry, Fuel cells, Batteries (Lithium-ion Batteries and EV Batteries), Corrosion control and protective coatings	**(7)**
5	**Spectroscopic Methods for strucutral analysis:** Principle and Applications (UV, IR, NMR, AAS/ICP-AES, SEM, TEM, XRD)	**(10)**
6	**Chemistry of Metal based and Composite Materials** Ceramic and Cement Materials, Metals and Alloys ,Phase change materials, Bio-inspired materials, Composite materials, Smart materials	**(7)**

Practicals	
Sr. No.	**Name of Experiment**
1.	Synthesis of metal-complex and determination of melting point
2.	Implementation of IR technique for the analysis of metal-complex synthesized
3.	Preparation of Metal-oxide by sol gel and hydrothermal method
4.	Characterization of metal–oxide using SEM technique by structural determination
5	Synthesis of an organic compound and chemicals analysis.
6	Structural analysis of organic compound by NMR technique.
7	Synthesis of polymer material and its analysis.
8	Application of UV spectroscopy for polymer functional group analysis
9	Investigation of redox chemistry of an inorganic material by Cyclic Voltammeter.
10	Application of open source software for chemical analysis and drug design.

Outcomes:

1	To be able to apply the fundamentals of chemistry towards emerging materials to benefit the societal needs.
2	To attain the essential analytical skills and designing of materials for various applications.
3	To be able to identify the chemical compositions required for designing of high performance materials.

Books:

1	Concise Inorganic Chemistry, by J. D. Lee, 5th Edition, 2003 (Chapman & Hall).
2	Organic Chemistry by S. M. Mukherji, and S. P. Singh, 2017 (Newagepublishers).
3	Principles of Physical Chemistry by Puri, Sharma and Pathania, 2008 (W.H. Freeman & Co).

4	Atkin's Physical Chemistry by Peter Atkins, Julio de Paula, 7th Edition (Oxford University Press).
5	Principle of Polymerization by G. Odian, 4th Edition, (John Wiley & Sons, Inc.).
6	D. S. Pavia, G.M. Lasmpman and G.S. Kriz: Introduction to Spectroscopy, 4th Edition, (Thomson learning, Indian Edition).
7	NPTEL web lectures: Chemistry of Materials, Engineering Chemistry I & III

Course Name	**:**	**Introduction to Environmental Sciences-I**
Course Code	**:**	**GS 1101 (Common to all branches)**
Credits	**:**	**2**
L T P	**:**	**2 0 0**

Course Objectives:
1. This course aims to acquaint students with the basics of Environmental Sciences. 2. To make them understand the importance of Environmental Sciences.

Total No. of Lectures – 28

S. No.	**Unit wise breakup**	**No. of Lectures**
1	Introduction to environmental studies: Multidisciplinary nature of environmental studies; Scope and importance; Concept of sustainability and sustainable development.	4
2	Ecosystems: What is an ecosystem? Structure and function of ecosystem; Energy flow in an ecosystem: food chains, food webs and ecological succession. Case studies of the following ecosystems :a)Forest ecosystem b) Grassland ecosystem c)Desert ecosystem d)Aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries)	8
3	Natural Resources: Renewable and Non-Renewable Resources: Land resources and Landuse change; Land degradation, soil erosion and desertification. Deforestation: Causes and impacts due to mining, dam building on environment, forests, biodiversity and tribal populations. Water: Use and over--exploitation of surface and ground water, floods, droughts, conflicts over water (international & inter--state).Energy resources: Renewable and non-renewable energy sources, use of alternate energy sources, growing energy needs, case studies.	8
4	Environmental Pollution: Environmental pollution: types, causes, effects and controls; Air, water, soil and noise pollution. Nuclear hazards and human health risks. Solid waste management: Control measures of urban and industrial waste. Pollution case studies.	8

Course Outcomes:
1. Students will be able to relate the importance of Environmental Sciences for sustainable development of society 2. Students will be able to understand the problems and remedies of Environmental Sciences

Text Books:

1	Environmental Science Ceonage Learning Publications, Miller G.T. and Spool Mar
2	Environmental Studies, Tata Mcgraw Hill Pub., Banny Joseph
3	Text book of Environmental Studies for U.G. Courses - University Press – ErachBharucna
4	Environmental Studies – from criteria to cure, Oxford Univ. Press, R. Raogopalan

SUGGESTED BOOKS:		
S. No.	**Name of Book/Authors/Publishers**	**Year of Publications/ Reprints**
1.	"Building Construction Punmia B.C, Punmia Arun Jain & Ashok Jain, Laxmi Publication (P) Ltd.	2012
2.	"Estimation and costing in Civil Engineering'', B.N Dutta, UBS publisher distributors.	2014
3.	"Engineering Materials", S.C. Rangwala, Charotar Publishing House.	2016
4.	"Building Construction", P.C. Varghese, PHI learning Pvt Ltd.	2014
5.	"Building Construction", Mckay W. Barry, Pearson Publication.	2013

Course Name	**:**	**Introduction to Environmental Science-II (GSC-II)**
Course Code	**:**	**GS1201 (Common to all branches)**
Credits	**:**	**2**
L T P	**:**	**1 0 2**

Course Objectives: This course aims to attract the attention of students towards understanding the chemistry of pollutants, their analysis and disposal along with introduction to green chemistry for Environment friendly processes and products.

Total No. of Lectures: 14

	Contents	No. of Lectures
1.	**Air Pollution:** Introduction, Air pollutants, Photochemical reactions in the atmosphere, Photochemical smog, Health effects and the usual ways to control air pollution	3
2.	**Water Pollution:** Types of Pollution, Contaminants and their sources, measurements and its control	3
3.	**Soil Pollution:** Inorganic and organic contaminants, Pesticides and herbicides, health effects and remedial measures, metal toxicology	3
4.	**Green chemistry for clean Technology:** Goals, Principles and applications	2
5.	**E-waste Management:** Introduction, Environmental impact/ health effects of e-waste exposure, Methods to dispose e-waste	3

Course Outcomes:

1. Students will be able to identify the source of contaminants in Water, Soil and Air and develop the strategies to minimize the levels of pollution
2. Students will understand the applications of green chemistry in mitigating the environmental pollution
3. Hands on training through lab experiments for chemical analysis of various pollutants.

Books:

1. Chemistry for Environmental Engineering and Science, Fifth Edition by Sawyer, McCarty and Parkin (Publisher: McGraw-Hill Education, 2003)
2. Environmental Chemistry, Seventh Edition by A.K. De (Publisher: New Age International (P) Limited, 2017)
3. Environmental Chemistry: Pollution and Remedial Perspectives by A.V. Salker (Publisher: Alpha Science International Limited, 2017)

Practicals	
Sr. No.	**Name of Experiment**
1.	Determination of total dissolved solid (TDS) by conductivity measurement
2.	Measurement of acid-base equilibria by pH meter in water/soil sample.
3.	Measurement of dissolved oxygen in given waste water sample
4.	Determination of organic pollutants (pesticides) in water/soil sample by extraction and IR analysis
5	Measurement of alkalinity and hardness in a given sample of water
6	Measurement of biological oxygen demand (BOD) in given sample of water
7	Measurement of chemical oxygen demand (COD) in given sample of water
8	Measurement of oil and greases in waste water by gravimetric analysis
9	Detection of heavy metal by complexation and UV-Visible spectrophotometer
10	Removal of toxic metals by chemical adsorption method

Course Name	**:**	**Introduction to Computing**
Course Code	**:**	**ES1101 (Common to all branches)**
Credits	**:**	**4**
L T P	**:**	**3 0 2**

Course Objective:
To develop logical skills so that students should be able to solve basic programming problems. To use programming knowledge to develop small projects including basic GUI design

Total No. of Lectures: 42

	Lecture wise breakup	**No. of Lectures**
1	**INTRODUCTION TO PROGRAMMING** Evolution of languages: Machine languages, Assembly languages, High-level languages. Software requirements for programming: System softwares like operating system, compiler, linker, loader; Application softwares like editor. Flowcharts. Algorithm, specification of algorithm. Industrial uses of programming in various domains	**3**
2	**DATA TYPES and OPERATORS AND EXPRESSION** Storing integers, numbers with decimals, characters and strings, typecasting. User input and output, use of command line arguments Operators: arithmetic operators, relational operators, logical operators, bitwise operators, miscellaneous operators. Expressions and their evaluation. Precedence and associativity rules.	**7**
3	**ITERABLE CONTAINERS and STATEMENTS** List, set, tuple and dictionaries; range function; difference between various iterable containers Decision making statements: if, if-else, nested if and if-else. Control statements: for & while loops, nested loops; Role of statements like break, continue	**7**
4	**FUNCTIONS and CLASSES** Advantage of modularizing program into functions, function definition and functioninvocation. Function arguments: default, keyword and positional arguments. Scope and lifetime of a variable. Recurrence relations and Recursion Advantage of using classes, defining class data members & functions and accessing using objects. Constructors and destructors in a class, parameterized constructors	**8**
5	**GUI design** Introduction to tkinter library, use of TK &mainloop methods, use of widgets like Button, Canvas, Checkbutton, Entry, Frame, MenuButton, Listbox, Menu, Scrollbar, Text, Message, Pack, Grid, place etc. for GUI design	**5**
6	**SORTING AND SEARCHING** Searching: Linear search, binary search and hash search. Sorting: Insertion sort, selection sort, bubble sort, quick sort, merge sort, heap sort, and Bucket sort. Time and space complexity of algorithms, comparing algorithms	**9**
7	**Problem Solving** Real-world programming problems	**3**

Total no. of turns: 14

List of Experiments:	
1	Implement programs to input/output various data types
2	Implement programs to use command line arguments
3	Implement programs making use of various operators
4	Implement programs making use of conditional statements and loops
5	Implement programs making use of iterable containers
6	Implement programs making use of functions and recursion
7	Implement programs performing file operations
8	Implement various searching and sorting algorithms
9	Project work including GUI design using tkinter

Course Outcomes: At the end of the course, students will be able to:	
1	Develop understanding ofthe fundamental concepts essential for programming.
2	Make efficient use of iterables, function and classes to programming problems
3	Develop simple GUI applications
4	**Learn to compare algorithms and improve efficiency of algorithms**

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Think Python, How to Think Like a Computer Scientist, Version 2.0.17 Allen Downey Green Tea Press Needham, Massachusetts	2012
2	Python Programming: An Introduction to Computer Science by John M. Zelle, Franklin, Beedle& Associates Inc	2015
3	Core python programming, Dr. R. Nageswara Rao, 2nd edition, Dreamtech press	2018

Course Name	**Engineering Drawing with CAD Software**
Course Code	**ES1201 (Common to all branches)**
Credits	**3**
L TP	**2-0-2**
Total No. Lectures	**28**

Course Objectives:

At the end of this course, the student should be able to understand the basic concepts of Engineering Drawing. The student should be able to visualize and draw the two- and three-dimensional objects. The student should also be able to understand the features associated with operations of the computer-aided design (CAD) software.

Total No. of Lectures – 28

	Lecture wise breakup	**Number of Lectures**
1	Introduction to Engineering Graphics, Concept of points and lines, System of Projections, Orthographic projections, Dimensioning.	4
2	Introduction to different types of CAD Softwares e.g. SolidWorks/AutoCAD/ CATIA etc., 2D-Sketching, Sketching Entities & Relation, 3D-Sketching, Editing and its Features, Dimensions, Sketch Tools, File handling	7
3	Projections of planes / lamina on reference planes, classification of primary and secondary planes, use of auxiliary planes, Exercises using CAD software	5
4	Classification of solids, Projections of solids on the basis of positions of the axis of various solids on reference planes and Sectioning of solids, Exercises using CAD software	6
5	Introduction to Perspective projection, isometric views, Isometric lines & Axes, conversion of orthographic views to isometric views and vice-versa, Exercises using CAD software	6

	List of Experiments:	**Number of Turns**
Exercises to be done using CAD software		
1	2D & 3D Sketching using various sketching tools.	2
2	Projection of planes.	2
3	Developments of 3D-parts.	2
4	Projection of solids.	2
5	Projection of Sectioning of solids.	2
6	Isometric and orthographic views.	2
7	Generating drawings of 3D-parts.	2

	Course Outcomes: At the end of this course, the students will be able to:
1	Understand the basic concepts of Engineering Graphics.
2	Visualize the actual objects and convert them in to readable drawings.
3	Understand the drawing standards, conventions and symbols that are in common usage.
4	Draw the common Engineering drawings using available Drafting softwares.
5	Come up with innovative conceptual ideas by using Drafting softwares.

Suggested Books:

Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Engineering Drawing, P. S. Gill, S.K. Kataria& Sons.	2012
2	Engineering Drawing, D.A. Jolhe, Tata McGraw Hill	2010
3	Engineering Graphics with SOLIDWORKS, David C. Plan chard, SDC Publications	2020

Course Name	**:**	**Introduction to Mechatronics**
Course Code	**:**	**ES 1301 (Common to all branches)**
Credits	**:**	**3**
L T P	**:**	**2-0-2**

Course Objectives:
The objective of the course content is to:
1: Impart knowledge and information about product design.
2: Development and control of intelligent systems for all aspects of life.

Lecture wise breakup		**No. of Lectures**
1	**Understanding Mechatronics** Mechatronics System, Evolution, Definitions of Mechatronics, Key Elements of Mechatronics, Mechatronics for all Civil, Metallurgical, Aerospace, Chemical, Architecture, Medical, Robotics, Defense, Agriculture, etc., Role of Mechanical, Electrical, Electronics, Computer Engineers in Intelligent Product and Process Design, Development and Control, Bio-mechatronics.	02
2	**Systems and Machines :** System, Classification of System, Mechanistic System Classification Based on Input Energy, Mathematical Model and Function, Machine, Parts of Machine, Concepts of Machine, Classification of Machines based on Function and Size.	02
	System Intelligence: Properties of Intelligent System, System Intelligence Levels, Human Intelligence System, Future Generation System Intelligence Level, Expressing System Intelligence.	02
3	**Sensor and Transducer :** Sensors in Mechatronics System, Difference between Sensors and Transducers, Classification of Sensors, Based on Sensor Output Signal, Sensor Input Physical Parameters, Sensor Accuracy (Smart/Intelligent Sensor), Performance Terminology, Static Characteristics, Dynamic Characteristics.	03
4	**Signal Conditioning Devices :** Signal Conditioning Processes,Application of Signal Conditioning Devices in Mechatronics based on Their Characteristics such as Diode, Transistor, SCR, DIAC, TRIAC, Op-Amps, Signal Filtering, Circuit Protection, Signal Conversion, ADC and DAC, Logic Gates, Flip-Flops, Register, Counters.	05
5	**Actuators:** Actuators, Types of Actuators, Mechanical Actuation System (i.e. Linear-rotary, Rotary-linear Mechanism, Gear, Bearing, Pulleyetc.). Electrical Actuation System (DC, AC, Stepper Motors), Pneumatic and Hydraulic Actuation System.	05
6	**Controllers :** Microprocessor, Microcontroller, PLC Controller& Their Architectures, Principles and Working Software Programs (Assembly/High Level),Interfacing Aspects, Application Examples.	05
7	**Robotics and Automation:** Evolution of Robots, Definitions, Types of Motions, Function, Governing Laws, Classification, Features and Components of Robots, System Automation .	04
	Total No. of Lectures	28

	LIST OF EXPERIMENTS	**Number of Turns**
1	**Experiment on Sensors & Transducers (Mechatronics Lab)**	
(i)	To study the characteristics of LVDT using linear displacement trainer Kit & compare with ideal characteristics.	01
(ii)	To measure the strain of the metal strip using strain gauge trainer kit & compare with ideal characteristics.	01
(iii)	To measure the angular displacement of resistive & capacitive transducer using angular displacement trainer kit & compare with ideal characteristics.	01
(iv)	To obtain the characteristics of RTD, Thermistor, thermocouple with hot and cold junction thermal trainer kit & compare with ideal characteristics.	01
2.	**Experiments on Signal Conditioning**.	
(a)	Experiments on Analog Devices	

(i)	PN Junction Diode	01
(ii)	Zener Diode	01
(iii)	Half wave rectifier	01
(iv)	Full wave rectifier	01
(b)	**Experiments on Digital devices**	
(i)	Logic Gates (AND, OR, NAND, NOR etc)	01
(ii)	Flip Flop (RS Flip Flop), D Flip Flop.	01
3	**Experiments on Controller**	01
(i)	Study of microprocessors, microcontroller, programmable logic controller (PLC)	
(ii)	PLC interfacing of I/O and I/O addressing.	01
(iii)	To perform any basic sequence programming using PLC.	01
4.	**Experiments on Actuators**	01
(i)	Study of mechanical, electrical, hydraulic/pneumatic actuators.	

Course Outcomes	
By the end of this course, the student will be able:	
1	To understand components of mechatronic system,
2	To design product and systems theoretically as well as practically with intelligence.

Suggested Books:

Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Mechatronics First edition by Tilak Thakur, published by Oxford University Press	2016
2	Mechatronics, Fourth edition, by W Bolton. ISBN 978-81-317-3253-3	2013
3	Dan Necsulescu Mechatronics published by Pearson Education (Singapore) Pvt. Ltd., Indian Branch, 482 FIE, Patparganj, Delhi India.	2001
4	Book by H M T Limited, Mechatronics Tata McGraw Hill Publishing Company Limited, New Delhi.	1988
5	Mechatronics Principles, Concepts & Applications by Nitaigour P Mahalik published by TMH	2003

Course Name	**:**	**Introduction To Electronics & Electrical Engineering**
Course Code	**:**	**ES1401 (Common to all branches)**
Credits	**:**	**2**
LTP	**:**	**2-0-0**

Course Objective:
To introduce to the students, the fundamental concepts of electronic devices, circuits and electrical systems for engineering applications.

Total Number of Lecture:28

	Lecture wise breakup	Number of Lecture
1	**Semiconductor Device sand applications**: Familiarizations with active and passive components Physics of p-n junction diode, BJT, JFET and MOSFET, diode as Rectifier, clippers and clampers, Transistor as an amplifier, Introduction to Audio amplifiers, Functional operation of OpAmp, concept of Oscillators, filters and their types	7
2	**Digital Electronics**: Introduction to logic gates, combinational circuits: adder, subtractor, multiplexer, demultiplexer, sequential circuit: flipflops, counters, registers, Analog to digital conversion, Digital to analog conversion and applications	5
3	**Communication Systems:** Various frequency bands used for communication, Block diagram of Analog and Digital communication, need of modulation, Analog modulation techniques (Amplitude and frequency), Digital modulation techniques (ASK, FSK, PSK,)	3
4	**Fundamentals of Electrical Engineering:** Introduction to circuit laws, Network theorems, Amplitude, Phase, Phase difference, RMS value and Average value of a AC signal, Active and Reactive Power, single phase and 3 phase systems,star delta connection, construction, working principle and speed control of AC and DC machines, Transformer: construction, working principle and applications	8
5	**Measurements:** Principle of measurement, voltage, current, power and energy measurement, analog and digital measurement system	5

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

1. Express the understanding of semiconductor devices (p-n Diode, BJT, MOSFET etc), and their applications.
2. Describe the functional operation of various analog and digital electronic circuits.
3. Solve basic electronic circuits using circuit laws and network theorems.
4. Describe the basic principle and working of fundamental electrical systems, ac dc motors and transformer etc.
5. Explain the basic principle of measuring electrical quantity such as voltage, current, power and energy.

SuggestedBooks:

Sr. No	Name of Book/Authors/Publisher	Year of Publication/ Reprint
1	Electronics Devices & Circuit Theory, RL Boylestead & L Nashelsky (PHI)	2009
2	Circuits and Networks: Analysis and Synthesis, Sudhakar and Shyam Mohan,TMH	2009
3	Electronic Communication Systems by G. Kennedy, McGraw Hill,4thEdition	2008
4.	Digital Principles And Applications, Seventh Edition, A. Malvino and D. Leach	2011
5.	Alexander, Charles K., and Sadiku, Matthew N. O., Fundamentals of Electric Circuits, 5th Ed, McGraw Hill	2013
6.	A K.Sawhney-A course in Electrical and Electronic Measurements and Instrumentation	Latest Edition

Course Name	**Strength of Materials**
Course Code	**ES1601 (For Civil, Mechanical, MMED and Production)**
Credits	**2**
L T P	**2-0-0**
Total No. Lectures	**28**

Course Objectives:
At the end of this course, the student should be able to understand the basic concept regarding the strength of material. The course will prepare the students to apply these concepts to engineering and applied sciences problems.

Lecture wise breakup		**No. of Lectures**
1	**INTRODUCTION:** Equations of static equilibrium, Concept of various forces/loads, stresses and strains developed due to these forces/loads, Uniaxial tensile test, Stress-strain diagrams for various types of ferrous and non-ferrous materials, isotropic and anisotropic materials, Compression test, impact test, fatigue test, hardness test, torsion and bending test as per ASTM standards	**3**
2	**SIMPLE STRESS & STRAIN:** Hooke's law, stress and elongation produced in various types of bars due to its own weight and applied axial force, Poisson's ratio, relationship between elastic constants, stresses and elongation produced in simple & composite bars due to axial, thermal and combined loading.	**5**
3	**2-D STATE OF STRESS ANALYSIS:** Generalized 2-D state of stress accompanied by shear stress, stresses on an arbitrary plane under this state of stress, sign conventions, complementary shear stress, principal stresses and principal planes, Different stresses determination through Mohr's stress circle approach in 2-D state of stress.	**5**
4	**SHEAR FORCE AND BENDING MOMENT IN BEAMS:** Classification of beams, supports and loads, Shear force (SF) &Bending moment (BM) in beams, sign conventions, Relation between rate of loading (w) with SFand BM. SF and BM diagrams of cantilevers, simply sported beams with or without overhang under different types of loading e.g. concentrate loads, uniformly distributed load, uniformly varying load, moment or its combinations, the point of contra-flexure	**5**
5	**BENDING & SHEAR STRESSES IN BEAMS**: Theory of pure bending, position of neutral axis, Bending equation, practical application of bending equation, review of moment of area concepts, variation of bending stress in various cross-sectional beams, shear stresses in beams, variation of shear stresses for different cross-sectional beams	**5**
6	**TORSION OF CIRCULAR SHAFTS:** Torsional equation of circular shafts, shear stress distribution, torsional rigidity, power transmitted by the shaft, comparisons of hollow & solid circular shafts, analysis of shafts in series and parallel mode	**5**

Course Outcomes: By the end of this course, the student will be able to:	
1	Understand the concept of stresses & strains, various types of materials, its properties & testing processes as per ASTM standards
2	Understand elastic constants and also be able to determine stresses & elongations in simple and composite bars under various types of loads
3	Will able to determine stresses on an arbitrary plane for a generalized 2-D state of stress accompanied by shear stress through analytical and graphical methods
4	Understand and be able draw shear force and bending moment diagrams for different types of beams under various types of loading
5	Will able to understand bending and shear stress equations and its application in determination of bending & shear stresses in different cross-sectional beams at any point across its length
6	Understand the torsional stresses for solid, hollow and composite circular shafts and its importance in power transmission.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Strength of Material - G. H. Ryder (MacMillan)	1969
2	An Introduction to the Mechanics of Solids – Crandall & Dahl (Mc-Graw Hill)	2012

3	Engg. Mechanics of Solids - E. P. Popav (Pearson Education)	2003
4	Strength of Material: D S Bedi, Fifth Ed.	2010
5	Strength of Material by R K Rajput, Fifth Ed.	2012

Course Name	**:**	**Communication Skills & Ethics**
Course Code	**:**	**HS1101 (Common to all branches)**
Credits	**:**	**3**
L T P	**:**	**2-0-2**

Course Objectives:

1. Thecourseaimstoenhancecommunicationskillsandcriticalthinkingskillsofthestudentsto further develop their personality so as to be more effective in personal and professional life.
2. The course further aims to provide basic knowledge in ethics, values, norms and standards to establish their importance in life and to enable students to self-assess and enhance their personality.

Total No. of Lectures – 28

Lecture-wise Breakup		**No. of Lectures**
1	**Introduction to Communication Process** Scope, Significance, Types, Levels and Tools of Effective Communication. Verbal, Vocal and Non-Verbal Skills	**(1)**
2	**Critical Thinking Skills** Developing Thinking Skills-Descriptive, Referential, Inferential, Discursive, Analytical, Evaluative, Creative and Lateral Using Texts and Various Media Forms:(Books, Newspaper Articles, Films, Social Visuals)	**(4)**
3	**Speaking Skills** Developing Speaking Skills PACESS-Governed (PACESS-Purpose, Audience, Content, Expression, Structure, Style) for Communication at Various Levels: Interpersonal, Group, Organization and Society	**(3)**
4	**Advanced Technical Writing** Job Application, E-mail, PACESS-Governed Short Essay, Memo, Notice, Agenda, Minutes, IMRD-BasedReport.	**(4)**
5	**Job Preparation** Sensitization to Building Portfolio, Resume, Interview Skills	**(2)**
6	**Introduction to Ethics** Concept, Nature, Scope, Functions and Factors influencing Ethics, Psycho-Social Theories of Moral Development – Kohlberg and Carol Gilligan, Broader Ethical Issues in Society (Research Based)	**(5)**
7	**Ethics and Business** Concept and Objectives of Business Ethics, Factors influencing Business Ethics, 3 C's of Business Ethics, Ethical Dilemmas in Business (Role- Play)	**(3)**
8	**Self-Awareness & Self-Development** Concept of Self Awareness, Self- Esteem, Self-Assessment – SWOT Analysis, Concept of Self-Development, Social Intelligence, Emotional Intelligence, Time and Stress Management, Positive Human Qualities (Empathy, Gratitude, Compassion, Forgiveness and Motivation), Personality Development Models – Johari Window, Myers Briggs Type Indicator Leadership Development	**(6)**

Total No. of Practical Sessions: 14

Practical Session Wise Breakup		**No. of Practical Sessions**
1	**Organizational Communication** Verbal, Vocal and Non-Verbal Communication at Various Levels, Self- Introduction, Speech, JAM	**(2)**
2	**Applying Critical Thinking Skills** Reading Comprehension, Book Review, Film Review, Social Visuals Interpretation and Critical Analysis .	**(4)**

3	**Speaking Techniques at Different Forums** Group Discussions, Making and Presenting Power Point Presentations	**(4)**
4	**Practice on Technical Writing** Job Application, Email, Memo, Notice, Agenda, Minutes, Report, Short Essay	**(3)**
5	**Towards Job Preparation** Sensitization to Building Portfolio, Resume, Interview	**(1)**

Course Outcomes:	
1	The students will gain greater proficiency in English language and its technical aspects for its effective use in personal and professional life.
2	Thestudentswillachievegreaterrefinementofpersonalitythroughawarenessandacquisition of forms and techniques of communication skills.
3	The students will be able to distinguish between right and wrong in both personal and professional life.

Suggested Books& E-Material		
S.No.	***Name of Book/ Authors/ Publisher***	***Year of Publications***
1	Technical Communication: Principles and Practices, III Edition, Meenakshi Raman and Sangeeta Sharma, OUP, New Delhi (with E-Material)	2017
2	English for Writing Research Papers, Adrian Wallwork, Springer, London, New York	2011
3	Business Ethics – Text and Cases", Murthy C.S.V., 1st Edition, Pubs: Himalaya Publishing House.	2014
4	"Issues and Ethics in the Helping Professions", Corey G., Corey M.S. and Callanan P., 8th Edition, Pubs: Brooks/Cole, Cengage Learning.	2010

	Reference Books and E-Materials	
1	Business Communication III Edition, RK Madhukar, Vikas Publication House Pvt. Ltd, Noida	2018
2	Body Language, Allan Pease, Sudha Publications Pvt Ltd., New Delhi	2004
3	Techniques of Writing Business Letter, Memos & Reports, Courtland L Bovee, Jaico Publishing House, Mumbai	2005
4	Bridging the Soft Skills Gap, Bruce Tulgan, Wiley, New Delhi	2005
5	A Guide to Gracious Living Etiquette & Life Skills, Jyoti Singh, Mohindra Publishing House	2017
6	TED Talks Videos on Ted.com (Not their Regional versions)	
7	"The Curse of Self: Self-awareness, Egotism and the Quality of Human Life", Leary M.R., 1st Edition, Pubs: Oxford University Press.	2007
8	Business Ethics", Hartman L.P. and Chatterjee A., 3rd Edition, Pubs: Tata McGraw Hill.	2006
9	Positive Human Qualities (web)	https://positivepsychology.com/
10	Theory of Moral Development (web)	https://www.verywellmind.com/kohlbergs-theory-of-moral-development-2795071

Course Name	**:**	**ARTIFICIAL INTELLIGENCE & MACHINE LEARNING**
Course Code	**:**	**ES1701 (Common to all branches)**
Credits	**:**	**3**
L T P	**:**	**2 0 2**
Type of Course	**:**	**Engineering Science Course (ESC) ESC-VII**

Course Objective:

- Students should learn the basic concepts and techniques of Artificial Intelligence.
- Students should be able to develop AI algorithms for solving practical problems.

Total No. of Lectures: 42

	Lecture wise breakup	**No. of Lectures**
1	**INTRODUCTION:** Artificial Intelligence and its applications, criteria of success, Intelligent Agents, Nature ofAgents, Learning Agents, AI Techniques, Importance, functions, advantages, and limitations of AI	6
2	**PROBLEM SOLVING TECHNIQUES:** State space search, control strategies, heuristic search, problem characteristics, production system characteristics., Generate and test, Hill climbing, Best first search, A* search, Constraint satisfaction problem, Mean-end analysis, Min- Max Search, Alpha-Beta Pruning, Additional refinements, Iterative Deepening	8
3	**KNOWLEDGE REPRESENTATION SCHEMES and LOGIC:** Mapping between facts and representations, Approaches to knowledge representation,Propositional logic, predicate logic, Resolution, Resolution in proportional logic and predicate logic, Clause form, unification algorithm	7
4	**NATURAL LANGUAGE PROCESSING AND EXPERT SYSTEM:** Basic Tasks of Natural Language processing, Expert systems, Expert system examples, Expert System Architectures, Rule base Expert systems, Non Monotonic Expert Systems,Decision tree base Expert Systems.	7
5	**PLANNING:** The Planning problem, planning with state space search, partial order planning, planninggraphs, planning with propositional logic, Analysis of planning approaches, Hierarchical planning, conditional planning, Continuous and Multi Agent planning	7
6	**Learning:** Introduction to Learning, Supervised learning, unsupervised learning, Reinforcement learning, Applications of learning	7

Total no. of turns: 14

	List of Experiments:	**No. of turns**
1	Implement various problem solving techniques	3
2	Implement knowledge representation techniques	3
3	Implement propositional and predicate logic	2

4	Implement various expert systems	3
5	Implement various learning techniques	3

Course Outcomes: At the end of the course, students will be able to:	
1	Develop an understanding of where and how AI can be used.
2	Design, implement and apply basic AI techniques.

Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of publication**
1	S. RUSSEL, P. NORVIG, Artificial Intelligence: A Modern Approach, Pearson, 3rd Edition.	2015
2	E. RICH, K. KNIGHT, S. B. NAIR, Artificial Intelligence, McGraw Hill Education, 3rd Edition	2017
3	R.S. SUTTON, A.G. BARTO, Reinforcement Learning: An Introduction, The MIT Press, 2nd Edition	2015

Course Name	**:**	**Basics of Economics**
Course Code	**:**	**HS2301**
Credits	**:**	**3**
L T P	**:**	**2-1-0**

Course Objective:

- To make students understand how society manages its scarce resources for achievingmaximum satisfaction.
- To discuss the economic aspects related to a consumer, firm, market and economy.

Total No. of Lectures – 28

	Lecture wise breakup	**No. of Lectures**
1	**Introduction to Economics** Why study Economics? Scope of Economics; Types of Economics; Conceptsof Economics:Wealth, Welfare and Scarcity; Economic Problem: Scarcity and Choice; Concept of Opportunity Cost; The Question of What to Produce, How to produce and for Whom to Produce; Economic Activities: Consumption, Production, Exchange, Distribution and PublicFinance; Relationship of Economics with other Social Sciences and Engineering	**(4)**
2	**Theory of Consumer Behaviour** Demand-Types of Demand; Determinants of Demand; Change in Demand: Movement and Shiftof Demand; How to Estimate Demand? Law of Demand, Elasticity of Demand and its Application in Present Scenario. Utility Analysis; Assumptions; Consumption Decision: Budget Constraint; Changes in Consumption Pattern; Laws of Consumption: Concept and Applicability of Law of Diminishing Marginal Utility and Law of Equi- Marginal Utility.	**(6)**
3	**Cost and Production Analysis** Cost Concept; Production and Cost; Cost in the Short and Long Run; Short- Run Cost and Output Decision; Cost and Output in the Long Run. Relationship between TC, AC and MC. Production: Scale of Production, Short Run Production Function; Long Run Production Function; Stages, Significance and Practical Application ofLaw of Variable Proportion and Law of Return to scale. Economies and Diseconomies of Scale: Concept and Types. Relevanceof Production and Cost Concept in Real Situation.	**(6)**
4	**Market Structure** Perfect Competition, Monopoly, Oligopoly and Monopolistic Competition; Comparison Between Different Forms of Market Structure with Real Life Examples; Government Policies towards Different Forms; Nature and Relevance of different Markets in Present Scenario.	**(3)**
5	**Basic Macro Economics Concepts** Importance of studying Macroeconomics; Interest Rates Determination; Sources of Interest Rate Differentials; Unemployment and Full Employment; Profit Concept: Functions of Profit; Economic Profit and Accounting Profit.	**(3)**
6	**National Income and Inflation** National Income Concepts; GDP, GNP, NNP; Measurement of National Income: Income, Expenditure and Value Added Methods; Types of Inflation;Role of Inflation in Economic Development.	**(3)**
7	**Economic Policies** Monetary and Fiscal Policy; Instruments of Monetary and Fiscal Policy; Role of Monetary andFiscal Policy in a Developing Country; Money: Functions; Determination of Money supply.	**(3)**

Total No. of Tutorials-14

Hour wise Breakup	**No. of Tutorials**
Tutorials based on Lectures	14

Course Outcomes:	
1	The students are expected to apply engineering knowledge to maximize profit, satisfaction and welfare.
2	The students are able to identify the forces that affect the economy.

Suggested Books:		
S.No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
	Text Books	
1	"Principles of Microeconomics", Stiglitz J.E. and Walsh C.E.,W.W. Norton &Company.	2016
2	"Principles of Macroeconomics", Stiglitz J.E. and Walsh C.E., Pubs: W.W. Norton & Company.	2016
	Reference Books	
1	"Managerial Economics: Foundations of Business Analysis and Strategy", Thomasand Mauris, McGraw Hill.	2017
2	"Principles of Economics", Greenlaw S.A., Shapiro D., Taylor T.,Pubs: OpenStax	2017

Suggested E-Material:		
S.No.	***Title/Name of Authors/(Type of material)***	***Retrieval Source***
1	"Managerial Economics", Mishra Trupti. (video)	www.nptel.ac.in/courses/110101005/
2	"Macro Economics", SinhaSurajit. (video)	www.nptel.ac.in/courses/109104073/
3	"Business Analysis for Engineers", Vaidhyasubramaniam S. (video)	www.nptel.ac.in/courses/110106050/

Evaluation Scheme		
S.No.	***Category***	***Marks***
1	Mid Term	20
2	Assignments/Quizzes/Case Study	20
3	Project Report and Presentation	20
4	End Term	40

Course Name	**:**	**French- Basic**
Course Code	**:**	**HS2302**
Credits	**:**	**3**
L T P	**:**	**2-1-0**

Course Objective:
The main aim of this course is to introduce students with basics of a foreign language and make them learnhow to communicate in a new language.

Total No. of Lectures – 28

Lecture wise breakup		**No. of Lectures**
1	Greetings/Politeness – Formal/Informal	**(2)**
2	Alphabet / Full name + maiden name / Verbs	**(2)**
3	Question-answer/subject pronouns	**(2)**
4	Questions - what / words	**(2)**
5	Asking and answering basic questions: age/date of birth/numbers and calendar/verb	**(2)**
6	Locating a place / giving information about one's region, city or country/Phone number/email/signs and punctuations/ Verb	**(2)**
7	Nationality/masculine/feminine	**(2)**
8	Prepositions/Countries/cities/Articles	**(2)**
9	Negative pronouns/tonic pronouns	**(2)**
10	Family members/possessive articles	**(2)**
11	Profession/work place/masculine/feminine	**(2)**
12	Like/dislike	**(2)**
13	Activities (sports/culture/instruments)	**(2)**
14	Verb/prepositions	**(2)**

Tutorials Total No. of Tutorials – 14

	Revision/exercise based on the lecture class.	**14**

Course Outcomes:	
1	The students will be able to express themselves in the foreign language.
2	The students will be able to make use of this language in their professional life in the globalized world.

Suggested Books:		
S.No.	***Name of Book/ Authors/ Publisher***	***Year of Publication/ Reprint***
	Text Books	
1	Saison 1, DelphineRebaud et al: Didier	2015
2	"Complete French", Graham G., Pubs: Hodder& Stoughton.	2012
	Reference Books	
1	"French Made Easy", Verma R., 1st Edition, Pubs: Goodwill Publishing House,NewDelhi.	2012
2	"French Made Easy", Khan F., Pubs: Lotus Press.	2010

Evaluation Criteria:

Assignments/Quizzes: 30 marks

Mid Term: 20 marks

End term: 50 marks

Total: 100 marks

Course Name	**:**	**General Psychology**
Course Code	**:**	**HS2303**
Credits	**:**	**3**
L T P	**:**	**2-1-0**

Course Objective:
The main aim of the course is to provide knowledge and understanding about important concepts in Psychology which will help the students in learning the applications of principles of psychology in personal and professional life.

Total No. of Lectures – 28

Lecture wise breakup		**No. of Lectures**
1	**Introduction to Psychology** Concept, Nature and Scope Methods of Studying Human Behaviour – Introspection Method, Observation Method,Experimental Method, Case History Method, Survey Method.	**(4)**
2	**Intelligence** Concept and Determinants of Intelligence; Theories of Intelligence and its Application: Spearman, Thurston, Guilford.	**(4)**
3	**Personality** Personality: Concept, Determinants of Personality, Trait Paradigm (Eysenck), Psychodynamic Paradigm (Freud), Measurement of Personality – Self Report Measures (EPQ), Projective Measures (TAT).	**(4)**
4	**Mental Health and Stress** Mental Health: Concept and Factors Affecting Mental Health Stress: Nature, Rections to Stress, Outcomes of Stress, Stress Management	**(4)**
5	**Learning and Memory** Learning: Concept, Reinforcement Principle and Learning, Managerial Implications Memory: Concept, Long Term Memory, Short Term Memory, Episodic Memory,Methods to Improve Memory	**(3)**
6	**Motivation** Nature and Types of Motivation: Extrinsic and Intrinsic Theories of Motivation and its Application: Humanistic and Need Theories	**(3)**
7	**Group Behaviour and Dynamics** Concept and Importance, Types of Groups, Group Development, Group Performance Factors , Conflict: Nature, Conflict Resolution, Case Study	**(4)**
8	**Leadership** Leadership: Nature and Importance, Leadership Styles: Authoritarian, Democratic, Paternalistic, Laissez faire, Transactional, Transformational	**(2)**

Total No. of Tutorials – 14

	Revision/discussions based on the lecture class	**14**

Course Outcomes:	
1	The students will learn the causes and dynamics of human behavior.
2	The students will be able to apply psychological principles to enhance their personal and professionallife.

Suggested Books:		
S.No.	***Name of Book/ Authors/ Publisher***	***Year of Publication/ Reprint***
	Text Books	
1	"Psychology", Ciccarelli S.K. and Meyer G.E., Pubs: Pearson India.	2007
2	"Introduction to Psychology", Morgan C.T., Weiss J.R., King R.A. and Schopler J., 7th Edition, Pubs: McGraw-Hill Education.	2004
	Reference Books	
1	"Fundamentals of Social Psychology", Baron R.A., Branscombe N.R., Byrne D. and Bhardwaj G., 1st Edition, Pubs: Pearson India.	2011
2	Organizational Behavior", Luthans F., Pubs: McGraw Hill Education.	2010

EVALUATION CRITERIA:

Assignments/ Quizzes/ Case Study/ Project/ PPT: 40 marks

Mid Term: 20 marks

End term: 40 marks

Total: 100 marks

Course Name	**:**	**Sociology**
Course Code	**:**	**HS2304**
Credits	**:**	**3**
L T P	**:**	**2-1-0**

Course Objective:

The main aim of the course is to make the students understand the role of theory in social sciences andto explain them how social problems interact and react with the larger society. This course also intends to make them learn whether the problem is evaluated on the macro or micro perspective and their cause and effect patterns.

Total No. of Lectures – 28

Lecture wise breakup		**No. of Lectures**
1	**Introduction to Sociology** Sociology as a Science, Impact of Industrial and French Revolution on the Emergence of Sociology, Contribution of Karl Marx, Emile Durkheim, Max Weber, AlwinToeffler to Sociology and its Application in present scenario, Relevance of Sociology for Engineering	**(5)**
2	**Basic Concepts** Society, Association, Institution, Culture Relativism, Social Structure, Social System, Socialization, Competition, Conflict, Accommodation, Social Mobility	**(2)**
3	**Society and Economy** Evolution of Society: Primitive, Agrarian, Industrial and Post-Industrial, Economic Systems of Simple and Complex Societies, Sociological Dimensions of EconomicLife, Market (free)Economy and Controlled (planned) Economy	**(4)**
4	**Industrial Sociology** Nature and Scope of Industrial Sociology, Pre-Conditions and Consequences of Industrialization, Impact of Automation and Industrialization on Society with Case Study	**(3)**
5	**Science and Technology** Ethos of Science and Social Responsibility of Science	**(2)**
6	**Social Change** Theories of Change and its Application to Sociology, Factors Role of Engineers indevelopment	**(4)**
7	**Indian Society** Traditional Hindu Social Organization, Caste System, Green Revolution, Working of the Democratic Political System in a Traditional Society, Problem of Education in India, Gender Discrimination, Economic Reforms: Liberalization,Privatization and Globalization, Strategies for Development in India, Case Studies	**(6)**
8	**Social Problems** Concept of AIDS, Alcoholism, Drug Addiction, Corruption with Case Study	**(2)**

Tutorials- 14

Hour wise breakup		**No. of Hours**
	Practical Work based on Lectures	14

Course Outcomes:	
1	The students will be able to identify the function and application of sociology theory insocialsciences.
2	The students will be able to understand how social class affects individual life chances.
3	The students will learn about social structure and how it shapes and influences socialinteractions.

Suggested Books:		
S. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
	Text Books	
1	"Sociology: Themes and Perspective",Haralambos M. and Holborn M.,Pubs: Collins Educational Publications.	2008
2	"An Introduction to Sociology", Dassgupta S. and SahaP., Pubs:Dorling Kindersley (India) Pvt. Ltd.	2012
	Reference Books	
1	"Industrial Sociology",Singh N., 1st Edition, Pubs: McGraw HillEducation (India).	2012
2	"Society in India: Concepts, Theories and Recent Trends", AhujaR., 1st Edition,Pubs: Rawat Publications.	2011

Evaluation Criteria

Assignments/ Quizzes/ Case Study/ Project/ PPT: 40 marks

Mid Term: 20 marks

End term: 40 marks

Total: 100 marks

Department Core Course

Course Name	**:**	**Physical Metallurgy**
Course Code	**:**	**MM 1211**
Credits	**:**	**04**
L T P	**:**	**3 0 2**

Course Objectives:

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

1. describe the basic elements of material science and its application to engineering fields.
2. explain the concept of phase diagrams, solidification principles and engineering of ferrous, non-ferrous,ceramics and polymers.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**Structure of Materials**: Levels of structure, structure property relationship, crystal geometry and structure determination, crystalline and non-crystalline states of solids, structure and crystallinity of long chain polymers, Imperfections in solids: point defects, geometry of dislocations, surface imperfections.	10
2	**Diffusion in Solids:** Interstitial diffusion, steady state and non-steady state diffusion, Fick's laws, The Krinkendall Effect, Examples of diffusional processes like homogenization, carburization of steel etc. Substitutional diffusion- self diffusion, vacancy diffusion, atomic mobility, diffusion along dislocations and interfaces.	6
3	**Phase Diagrams:** Binary phase diagrams: simple phase diagrams, Gibbs phase rule, lever rule, effect of temperature on solid solubility, miscibility gap, ordered alloys, eutectic systems, phase diagrams with intermediate phases	12
4	**Crystal Interfaces:** Boundaries in single phase solids-low angle and high angle boundaries, thermally activated grain boundary migration, interfaces in solids-fully coherent, semi-coherent and incoherent interfaces, interfacial energy effects, second phase effects, examples of diffusion controlled and interface-controlled phenomena's.	8
5	**Solidification** Nucleation in pure metals, Growth of pure solid, alloy solidification, solidification of ingots and castings, solidifications of fusion welds, solidification during quenching from the melt, metallic glasses	6

List of Experiments:		**Number of Turns**
1	To study design, principle and application of basic tools of wide use to a Metallurgist such as a Metallurgical microscope, a Hardness Tester, a Image Analyzer.	2
2	To study design, principle and application of Furnace and Thermocouple.	1
3	To study design, principle and application of Scanning Electron Microscope.	1
4	T study and compare the difference between solidification Behaviour of pure metal and an alloy.	1
5	To observe the segregation of solute rich phase in the casting.	1
6	To carry out Homogenization annealing for removal of segregation in casting.	1
7	Qualitative and Quantitative Metallographic analysis and establishing correlation with phase diagram of thegiven alloy system: a. Recognition of the phase and state of material from the microstructure. b. Finding out the weight % of carbon in ferrous alloys from the microstructure w.r.t Hypo-, Hyper- phasesand their morphologies.	2
8	Alloy Development: a. To study the effect on microstructure and mechanical property. b. To study the solidification defects such as Segregation, Porosity etc.	2
9	To observe the Line Defects in given samples.	1
10	To observe the Surface Defects in given samples.	1
11	To observe the Volume Defects –Metallographic observation of Dislocations, Grain Boundaries, Twin Boundaries, Inclusions and precipitates in given samples.	1

Course Outcomes:
The student is able to 1. establish his understanding for crystal structure, phase diagrams and their applications, principles of solidification of metal, polymers and inorganic glasses. 2. Student will be able enough to apply these concepts in various application areas.

Suggested Books		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1.	Introduction to Physical Metallurgy/ S. H. Avner/ McGraw Hill/	2017
2	Materials Science and Engineering/ V. Raghavan/ Prentice Hall, New Delhi	2015
3	Fundamentals of Materials Science and Engineering/ W D Callister Jr./ John Wiley and sons/ 9^{th} Edition.	2014
4.	Physical Metallurgy Principles/ Reza Abbaschian, Lara Abbaschian and Robert Reed-Hill/ Cengage Learning India	2013

Course Name	**:**	**Metallurgical Thermodynamics and Kinetics**
Course Code	**:**	**MM 1212**
Credits	**:**	**04**
L T P	**:**	**3 1 0**

Course Objectives

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

1. apply the laws of thermodynamics to open and closed material systems and to analyze the spontaneity of a chemical reaction.
2. derive the combined statement of the first and second laws of thermodynamics.
3. calculate the configurational entropy of a multicomponent system, the standard enthalpy change, standard free energy change and standard entropy change of a phase change or chemical reaction at any temperature.
4. use Le Chatelier's principle to determine the direction of shift in reaction equilibrium.
5. understand the reaction mechanism in different heterogeneous systems.

Total No. of Lecture-42

Lecture wise Breakup		**Number of Lectures**
1.	**Law of Thermodynamics** First, second and third laws of thermodynamics, Free energy, Enthalpy, Entropy, Gibbs Helholtz Equations, Maxwell's relations, Clausius Clayperon equation, Stability, Configurational entropy and thermal entropy.	10
2.	**Behaviour of Solutions** Partial Molar properties, Gibbs Duhem equation, Ideal & Non-Ideal solutions, Raoult's Law, Henry law, Sieverts law, Regular solutions, Chemical potential, solution models, quasi chemical theory.	8
3.	**Phase Equilibrium** Equilibrium constant, Activity, Ellingham and phase stability diagrams, Phase equilibria, Evolution of phase diagrams, Metastable phase diagrams, Calculation of phase diagrams. Thermodynamics of point defects, surfaces and interfaces, Adsorption and segregation phenomena.	10
4.	**Fundamental of Kinetics** Thermodynamics versus kinetics, Reaction mechanism in homogeneous systems like solid-solid and liquid-liquid systems, Reaction mechanism in heterogeneous systems like gas-solid, solid-liquid systems, Rate controlling step and rate equation, Basics, first, second, third, and zero order reactions, Collision theory, Theory of absolute reaction rates, Activation Energy.	10
5.	**Kinetics study of Metallurgical Processes** Reduction of oxide ores, Kinetics of roasting and smelting.	4

Course Outcomes:

Student will be able to:

1. explain metallurgical thermodynamics concepts to perform equilibrium calculations and to perform thermodynamic calculations.
2. analyze binary phase diagrams and formulate / solve thermodynamic problems for real material and processes.

Suggested Books		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1.	Introduction to the Thermodynamics of Materials / David R. Gaskell and David R. Gaskell/ CRC Press / 6th edition	2017
2.	Metallurgical Thermodynamics/Ahindra Ghosh/ Printice hall India(P) Ltd.	2008

Course Name	**:**	**Extractive Metallurgy for Non-Ferrous Metals**
Course Code	**:**	**MM 1213**
Credits	**:**	**04**
L T P	**:**	**3 0 2**

Course Objectives
At the end of the course the student will be able to: 1. explain various techniques, unit process and operations used in metal extraction and refining. 2. apply the fundamental knowledge for design of a reactor and process flow charts.

Total No. of Lectures-42

Lecture wise Breakup		**Number of Lectures**
1	**Scope o f Mineral Processing and Pre-Concentration Techniques** Concept for mineral, ore and gangue. Classification and their processing for enrichment, Physiochemical principles of concentration techniques. Froth floatation, Electrostatic and magnetic separators, Pre-concentration techniques. Fused salt technology, Non aqueous technology	7
2	**Unit Operations in Extractive Metallurgy** Industrial units used in metallurgical industry for roasting, calcinations and smelting furnaces, Their design, constructions, advantages and disadvantages	5
3	**General Methods of Extraction** Pyrometallurgy: Calcination, Roasting, Predominance area diagram, Smelting, Roasting and Smelting. Hydrometallurgy: Leaching techniques and its variables, Types of leaching. Role of oxygen in leaching operations. Solvent extraction, ion exchange precipitation, electrolysis	7
4	**General Methods of Refining** Sublimation, Distillation, Fractional Distillation, Crystallization, Liquation, Fire refining, Electrolytic Refining, Zone refining	7
5	**Extraction of Metals** Refining of metals with reference to Physio-chemical principles. Different methods of purification of metal from oxides, sulphides, halides, The various flow sheets of the production of Aluminum, Copper, Nickel, Lead, Zinc, Tin, Gold, Silver, Magnesium and Titanium	14

Sr No	**List of Experiments**	**Number of Turns**
1	To study reducibility of Aluminum ore	1
2	To study calorific values liquid fuel	1
3	To study oxidation and roasting	1
4	To beneficiate chalcopyrite ore by froth flotation and establishing the relation of its operation variables with yield	1
5	To establish the parameters for reduction kinetics of concentrated Chalcopyrite ore	1
6	To produce agglomerate by fines of bauxite through Sintering and palletization	1
7	To study and understand the kinetics of reduction of Pallets/ores	1
8	Design a process for understanding the solidification defects in Aluminum with the help wax casting	1
9	Study, evaluate and plot the volume percent of piping in the Aluminum ingot castings versus the super heats on the in wax casting	1
10	Design the experiment on wax casting to understand directional solidifications in aluminum	1

	ingots. Plot the variation	
11	To study temperature distribution of tubular furnace	1
12	To find viscosity of solutions by Brookfield viscometer	1

Course Outcome:
Student will be able to 1. analyze and develop concentration techniques for extraction 2. understand the pyrometallurgical and hydrometallurgical extraction processes 3. apply concept /fundamentals for purification of metals

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

Course Name	**:**	**Phase Transformation**
Course Code	**:**	**MM 1221**
Credits	**:**	**04**
L T P	**:**	**3 1 0**

Course Objectives
At the end of this course the student will be able to explain: 1. phase transformation from liquid and solid state, 2. effect of time and temperature on microstructure, 3. TTT diagram and design heat treatment for given structural or property requirement.

Total No. of Lecture-42

Lecture wise Breakup		**Number of Lectures**
1.	**Thermodynamics** Gibbs free energy, Equilibrium and Chemical potential, Gibbs phase rule, Gibbs free energy vs. composition diagram, Types of binary phase diagrams, Lever's rule, Phase rule, Ternary diagrams, Kinetics of phase transformations.	6
2.	**Solidification** Liquid to solid transformation, Homogeneous nucleation, Heterogeneous nucleation, Nucleation and growth rate. Eutectic Transformation	7
3.	**Solid to Solid transformation** Homogeneous nucleation, Heterogeneous nucleation, Nucleation and growth, Overall transformation rate.	3
4.	**TTT Diagram** Origin of TTT diagrams, Avrami Model, Johnson-Mehl Model, Applications of the concepts of nucleation & growth in TTT/CCT diagrams, Eutectoid transformation, Bainitic transformation, Ordering Transformations, Massive transformation.	15
5.	**Diffusionless Transformation** Martensitic transformation in steels, Martensitic transformation in shape memory alloys.	3
6.	**Precipitation** Precipitations, Cellular Precipitation, Spinodal decomposition.	4
7.	**Tempering of Ferrous Martensite** Carbon segregation, ε-Carbide, Cementite, Alloy carbides, Effect of retained austenite, Recovery, Recrystallization and grain growth, Temper embrittlement.	4

Course Outcomes:
Student will be able to: 1. design a process involving phase transformation to meet a property requirement for an engineering application 2. establish heat-treatment or a suitable process to achieve desired structure and establish structure property correlation

Suggested Books		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1.	Phase Transformations in Metals and Alloys / David A. Porter, Kenneth E. Easterling, and Kenneth E. Easterling / CRC Press / 3rd edition	2009
2.	Physical Metallurgy Principles/ Reza Abbaschian, Robert E. Reed-Hill/ Cengage Learning/ 4th edition	2008

Course Name	**:**	**Materials Characterization**
Course Code	**:**	**MM 1222**
Credits	**:**	**03**
L T P	**:**	**2 0 2**

Course Objectives
At the end of this course the student will be able to: 1. understand the fundamental concepts of different characterization methods. 2. analyze characterization methods for the determination of the result of composition, structure and properties of materials.

Total No. of Lectures – 28

Lecture wise breakup		**Number of Lectures**
1	**Macroscopic Examination** Meaning/importance/need/role of examination of material, Importance & scope of macro-etching, Sulphur/Phosphorus/Oxide Printing, Flow Lines.	4
2	**Metallography** Principle, Construction and working of metallurgical microscope, Various properties of microscope objectives, Defects in lenses & their remedies, estimation of grain size, grain boundary area, relevance of light microscopy ideas to electron microscopy.	5
3	**Electron Microscopy** Scanning Electron Microscope (SEM): Principle, construction and operation of SEM, Interaction of electron beam with specimen, Study of fractured surfaces, Energy and wavelength dispersive spectroscopy, Field Emission Scanning Electron Microscope (FESEM). Transmission Electron Microscope (TEM): Principle, construction and operation of TEM, Interaction of electrons with specimen, Preparation of specimens, Selected area diffraction, Indexing of diffraction patterns.	6
4	**X-Ray Diffraction Techniques** Bragg's condition of diffraction, X-ray scattering, application of X-ray diffraction- phase identification, estimation of crystallite size, residual stress, X-ray Fluorescence (XRF).	5
5	**Spectroscopy Techniques** UV-Vis Spectroscopy, FTIR Spectroscopy Analysis, X-ray Photoelectron Spectroscopy (XPS).	4
6	**Thermal Analysis Techniques** Principles of Differential Scanning Calorimetry (DSC), Differential Thermal Analysis (DTA), Dilatometry, Thermogravimetric Analysis (TGA).	4

List of Experiments		**Number of Turns**
1	To analyze given samples using metascope for different elements and spark test for carbon content.	2
2	To study flow lines in a given forged sample.	1
3	To study segregation of sulphur and phosphorus by sulphur printing and phosphorus printing.	1
4	To study the microstructure and volume of different phases in the given metallic sample using optical microscope.	2
5	Chemical analysis using energy dispersive energy dispersive analysis in SEM (spot and line analysis).	2
6	To study the fracture surface of metal specimen using SEM.	1
7	To study spectroscopic analysis for Qualitative/ Quantitative analysis of given sample.	1

8	To study the DSC/DTA analysis of given sample.	1
9	Determination of phases in multiphase powder sample using XRD.	2
10	Estimation of crystallite size using Scherrer formula.	1

Course Outcomes
Student will be able to: 1. understand the principle of materials characterization techniques. 2. apply of characterization techniques for different applications. 3. analyze and interpret the results of different characterizations required for the characteristics of materials.

Suggested books		
S. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Materials Characterization: Introduction to Microscopic and Spectroscopic Methods / Y. Leng / John Wiley & Sons/ 1st edition.	2013
2	Spectroscopy of Organic Compounds / P S Kalsi / New Age International /6th edition.	2007
3	Elements of X-Ray Diffraction / B. D. Cullity, S.R. Stock / Pearson / 3rd edition.	2001
4	Electron Microscopy and Analysis / P.J. Goodhew, J. Humphreys, R Beanland / Taylor and Francis / 3rd edition.	2000
5	Principles of Metallographic Laboratory Practice / G L Kehl / McGraw-Hill / 1st edition/	1980

Course Name	**:**	**Mechanical Behaviour of Materials**
Course Code	**:**	**MM 1223**
Credits	**:**	**04**
L T P	**:**	**3 1 0**

Course Objectives:

At the end of this 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 surface defects and volume defects. design a process based on strengthening mechanisms for a given application.
3. apply mechanisms of material failures fracture, fatigue and creep for failure analysis.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**Concepts of Stress and Types of Stress** Concepts of Stress and types of Stresses, Concepts of Strain and types of Strain, Units ofstress and other quantities.	2
2	**Elastic, Anelastic and Viscoelastic Behaviour** Elastic behaviour: Atomic model of elastic behaviour, The modulus as a design parameter, Rubber like elasticity. Anelastic Behaviour: Relaxation Processes. Viscoelastic behaviour: spring dashpot models.	4
3	**Stress and Strain Relationships for Elastic Behaviour** Description of stress at a point, state of stress in two dimensions, state of stress in three dimensions, Description of strain at a point, Hydrostatic component of stress, Elastic Stress – Strain relations, Calculation of Stresses from Elastic Strains, Strain Energy, Anisotropyof Elastic behaviour, Stress Concentration	3
4	**Plasticity of Materials** The Flow Curve, True Stress and True Strain, Yielding and plastic flow, Dislocations thebasis for yield.	2
5	**Dislocation Theory** Dislocation during growth of crystals; Theoretical and observed yield stress, geometry of dislocations. Burgers Vector, Right hand convention - Types of dislocations loops and motion out of crystals strain energy of mixed dislocation two hard particles; simple relationship for forces between dislocation vector notation of dislocation in crystal systems; combination of dislocation stacking fault energy; motion of extended dislocation; construction Frank dislocation; Cross slip; double jump; Geometrical characteristics of dislocation; Interaction of dislocations (simple cases); Motion of kinked and Jogged dislocation; Non conservation method Motion creation of vacancies, Frank Read source, Sessile dislocations Lomer- Cotrell, stair-rod; width of dislocation; Pile up of dislocation, solid solution strengthening anti-phase boundary; Yield unit; Luder bands.	14
6	**Micro-Plasticity of Crystals** Slip planes and slip directions, r esolved shear stress, strain hardening and recovery ofsingle crystals, Twinning, Grain boundary sliding and diffusional creep.	5
7	**Plastic Deformation** Grain boundaries, Strain hardening, strain aging, The tensile stress strain curve:temperature dependence, strain rate, strain rate and temperature, Creep.	3
8	**Cold Worked Structure** Recovery, Recrystallization and Grain Growth.	2
9	**Strengthening Mechanisms** Cold working and annealing: Recovery, Recrystallization and Grain Growth, dynamic recovery, strain/ work hardening, solute hardening or solid solution strengthening, precipitation hardening, dispersion hardening, grain refinement.	3
10	**Fracture** Types of fracture- ductile fracture, brittle fracture; Theoretical fracture stress, Griffith theory, Orowan Theory, Comparison with equation based on stress concentration Crack velocities; Inglis equation; Dislocation model of crack nucleation Zener model, Cotrell- Hull model in BCC metals. Fracture toughness, The ductile to brittle transition. Methods of protection against fracture- surface treatment, compressive stresses.	4

Course Outcomes:

The student will be able to:

1. explain concepts of stress and strain, analyze dislocation interactions with other defects.
2. To apply dislocation theory to explain various plastic deformation phenomena, strengthening mechanisms and fracture mechanisms.
3. Solve numerical problems based on this course and engineering applications.

Suggested Books:

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1.	Dislocations and mechanical Behaviour of materials/ M.N.Shetty/ PHI Learning Pvt. Ltd.	2013
2.	Mechanical Behaviour of Materials/ Marc André Meyers, Krishan Kumar Chawla/Cambridge University Press	2009
3.	Mechanical Metallurgy/G.E Dieter adapted by David Bacon/ McGraw-Hill Book Company	1988
4	The structure and properties of materials, volume III, Mechanical Behaviour/H.E Hayden, William G Moffatt, John Wulff /Willey Eastern Ltd.	1986

Course Name	**:**	**Iron Making Technology**
Course Code	**:**	**MM 1224**
Credits	**:**	**03**
L T P	**:**	**3 0 0**

Course Objectives

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

1. the basic concepts of Ironmaking for integrated and primary iron producing Industry and its research developments.
2. analyze national and international developments in manufacturing of pig iron, its quality and its technology.,

Total No. of Lecture-42

Lecture wise Breakup		**Number of Lectures**
1.	**Introductory Thermodynamics** Introduction to the thermodynamics and basic principles of Extractive Metallurgy	5
2.	**Blast Furnace Design and Process** Plant layout and Auxiliary Equipment, Blast Furnace: Design Parameters, constructional details & their importance in stability of structure. Design improvement in the recent past for efficient Iron Making Practice, Economy of the process and its competitive advantages with respect to the modern Processes.	7
3.	**Feed Preparation** Need, and Importance for feed preparation, Agglomeration Techniques and their variables as blast furnace feed	4
4.	**Physio Chemical changes in Blast Furnace and Slag chemistry** Relevant systems in the blast furnace which guides the physio chemical change of the furnace. Oxygen potential, gas diffusion Slag – its types, nature and properties for efficient operation	7
5.	**Irregularities and improvements in design and operations of BF** Irregularities in the blast furnace operation and their remedies Improvement in blast furnace operation with High top pressure, Humidification, Oxygen enrichment etc.	3
6.	**Auxiliary Technologies for Iron Making** Low shaft Furnace – introduction, operation, application and advantage Electric Arc Furnace – introduction, operation, application and advantage Sponge iron technique – An important tool to combat present problem of low grade coke. Operation and thermodynamics of the Sponge Iron making techniques.	4

Course Outcomes:

Student will be able to

1. analyze the processes of pig iron production for its physiochemical change in different technologies and apply it for the developments in the industry in future.
2. design the correlation of the variable of process parameters for advances in recent future.

Suggested Books:

Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	The manufacture of iron and steel (Vol. I and II) Bash forth, R.G/ Andesite Press	2017
2	Iron Making and Steelmaking: Theory & Practice / Ahindra Ghosh, Amit Chatterjee/ PHI	2008
3	Principles of Blast Furnace (Iron Making)/ A.K. Biswas/ Cootha.	2003
4	Iron and Steel Production /K. Bugayev, Y. Konovalov / Books for Business	2001
5	Making, Shaping and Treating of Steel (Iron Making) / David H. Wakelin/ The AISE Steel Foundation	1999

Course Name	**:**	**Metal Casting Technology**
Course Code	**:**	**MM 1311**
Credits	**:**	**04**
L T P	**:**	**3 0 2**

Course Objectives:
All the end of this course, the student will be able to 1. explain basics of metal casting, its types, designing patterns cores and molding. 2. describe sand casting process, foundry melting furnaces. 3. design for feeding and gating. 4. establish structure property correlation with casting process and casting defects.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**Introduction** Casting as a process of Manufacturing, History of casting practices, Basic steps involved in the making of sand casting, Process chart of casting, Layout of a foundry, The features of casting problem; a survey and scope of foundry industry.	3
2	**Patterns and Core Boxes** Types, allowances, functions, materials used for pattern/core making.	2
3	**Molding Processes** Molding practices, Odd side, three-part, loam, sweep & pit molding, stack molding.	2
4	**Molding Machines, Equipment and Mechanization** Machines for sand mixing and preparation of moulds, muller, jolting, squeezing, jolt-squeezing, slinging, blowing and shooting machines; their functions & characteristics.	4
5	**Molding Sands** General properties of molding sands, basic ingredients, additives, testing of molding sands – moisture content, strength/GCS, permeability, mold hardness, clay content, AFS no.	4
6	**Cores and Core Materials** Core making and machine used, various core making processes, venting, core assembly, core setting, core prints and chaplets, Chills, core knock out and disposal, testing of core sand and core coatings, cores and casting defects, Core dryer and Air circulation.	4
7	**Solidification of Metals** Freezing of pure metals and alloys, shrinkage, fluidity and spiral test, hot tearing and cracking, inoculation, metal filtration.	3
8	**Pouring and Feeding of Casting** Pouring ladles, gating system, progressive and directional solidification, types of gates, design of gating system, fluid flow, factors involved in gating design, pouring time, choke area, sprue-runner- gate ratios, Riser-theoretical considerations, function, shape, location, types.	5
9	**Melting of Metals** Cupola furnace: construction and operation, coke bed height, various types of cupolas-cold/hot/divided blast, coke bed and stack gases, melting rate, combustion and melt temperature, induction furnace.	4
10	**Casting Design** Factors affecting casting design, common design rules.	2

11	**Shakeout, Fettling, Cleaning and Inspection of Casting**	2
12	**Casting Defects and Diagnosis by NDT** Inclusions blow holes, pin holes and porosity, shrinkage, misrun, cold shut and cold lap, metal penetration, scab and rat tails, parting line shift and mismatch, sand drops and mold brake, defect diagnosis by radiography, ultrasonic, magnetic methods and eddy current techniques.	5
13	**Energy Conservation and Environment Protection**	2

List of Experiments:		**Number ofTurns**
1	To study the charge and heat balance of the cupola/arc and induction melting furnaces.	3
2	Sand Testing i. To study the size, shape and distribution of pure dry silica sand sample. ii. To find out the AFS number of given sand sample. iii. To find out the clay content in the given sand sample by washing. iv. To find out the active and dead clay content in the given sand sample. v. To find out the permeability of the given moulding sand. vi. To study the effect of clay and water content on strength (gcs) of moulding sand by preparing sands of different clay and moisture contents. vii. To find out the water content by conventional and rapid moisture teller in the given sand sample. viii. To find out the mold and core hardness using mould and core hardness testers.	6
3	i. To prepare a green sand mould in foundry workshop. ii. To melt and cast ferrous and non-ferrous metals.	3
4	To study the layout of an industrial casting unit.	1
5	To study the various casting defects by visiting a nearby foundry.	1

Course Outcomes:

Student will be able to:

1. apply fundamentals of sand and other castings.
2. apply theory of solidification on cast metals and alloys.
3. design moulds and pattern for making castings.
4. analyze the economics, environment, health and safety aspects for various applications.

Suggested Books:

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

Course Name	**:**	**Steel Making Technology**
Course Code	**:**	**MM 1312**
Credits	**:**	**03**
L T P	**:**	**3 0 0**

Course Objectives
At the end of this course the student will be able to: 1. to apply the basic concepts of steelmaking for steel making industry and its research developments. 2. analyze national and international developments in manufacturing of steel, its quality and its technology,

Total No. of Lecture-42

Lecture wise Breakup		**Number of Lectures**
1.	**Steel Production and Technology** Steel: As Engineering material and its applications National targets for steel production and planning at national level. International outlook on production and the technologies Challenges at national and international levels	5
2.	**Thermodynamics and Chemistry of Steel Production** The thermodynamic principles of steel making involving and Physio chemical aspects of steel making reactions, The controlling/removal parameters for carbon, sulphur, phosphorous, silicon & manganese Slags of Steel Making, their properties and the theories involved in the mass transfer	7
3.	**Pre-treatments to Pig Iron** Pre-treatment of Pig Iron with ladle treatments Ladle desiliconization, desulphurization	4
4.	**Technologies of Steel Production** Open Hearth Furnace, Electric Arc Furnace, LD, Kaldo process details, construction, its principle for its operation, Basic Oxygen Processes – Principle of Operation & mechanism; its merits and limitations	7
5.	**New Developments in Steel Making** Modern pneumatic process and their development. Secondary processes of steel refining viz. Ladle furnace, AOD, VOD, and ESR. Its design considerations and other important characteristics, Physicochemical aspects of the reactions.	3
6.	**Gas Metal Interaction** Vacuum, Argon and Recycling methods employed for degasification of steel. Gas Metal Interaction during different Teeming Processes and Mechanism of gas absorption via entertainment during teeming of molten metals, Solubility of oxygen in liquid metals.	4
7.	**Solidification of Steel** Solidification of Steels and its effect on Ingot types and solidification defects	4
8.	**Continuous casting of Steels** Introduction to the technology of CCP and latest developments, Continuous Casting (CCP) – Process details	

Course Outcomes:
The student will be able to: 1. analyze the processes of steel making for its physiochemical change in different technologies and apply it for the developments in the industry in future. 2. design the correlation of the variable of process parameters for advances in steel making processes

Suggested Books		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1.	The manufacture of iron and steel (Vol. II and IV) Bash forth, R.G/ Andesite Press	2017
2.	Continuous Casting of steel: Basic principles/Bruce Kozak and Joseph Dzierzawski/ American Iron and Steel Institute	2015
3	Iron Making & Steelmaking: Theory & Practice /Ahindra Ghosh, Amit Chatterjee/ PHI	2008
4	Steel Making /A.K. Chakrabarti/Prentice-Hall of India Pvt. Ltd.	2007
5	Making, Shaping and Treating of Steel (Iron Making)/ David H. Wakelin/ The AISE Steel Foundation, 11th Edition	1999

Course Name	**:**	**Mechanical Working of Metals**
Course Code	**:**	**MM 1313**
Credits	**:**	**03**
L T P	**:**	**3 0 0**

Course Objectives

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

1. apply the concepts of stress and strain to explain the elastic and plastic Behaviour of the material.
2. correlate the mechanical Behaviour of materials with dislocations and defects.
3. design a process based on strengthening mechanisms for given applications.

Total No. of Lectures-42

Lecture wise Breakup		**Number of Lectures**
1	**Fundamentals of Metal Working** Forming processes, mechanics of metal working, flow stress determination, temperature in metal working, strain rate effects, metallurgical structure, friction and lubrication, deformation zone geometry, workability, residual stresses, experimental techniques for metal working processes, computer aided manufacturing.	**12**
2	**Forging** Types of forging, forging equipment, forging in plain strain, open die and close die forging, calculation of forging loads in closed die forging in different friction conditions, forging die materials, forging defects, residual stresses in forgings, problems.	**6**
3	**Rolling** Rolling processes, rolling mills and the materials used for rolls, hot rolling, cold rolling, rolling of bars and shapes, forces and geometrical relationships in rolling under different friction conditions, simplified relationships in rolling load, rolling variables, problems and defects in rolled products, selection of rolling mills and the sequence of rolling operations for a given rolled product, problems, extrusion processes, extrusion equipment, die materials, hot extrusion, deformation, lubrication, and defects in the extruded products, analysis, cold extrusion, hydrostatic extrusion, problems.	**12**
4	**Drawing of Rods, Wires and Tubes** Rod and wire drawing, analysis of wire drawing in different friction conditions, tube drawing processes, analysis of tube drawing, drawing equipment, defects and residual stresses in rod, wire and tubes.	**5**
5	**Non-Conventional Forming Operation** Explosive forming, magnetic forming, electric discharge forming, super plastic forming for super plastic materials like Zn-22Al and Ti-6Al-4V alloys, combination of super plastic forming and diffusion bonding, die materials used for super plastic forming, peen forming of thin sheet metals, laser forming.	**7**

Course Outcome:

Student will be able to:

1. understand the fundamentals for metal forming.
2. apply concepts to calculate rolling and forging parameters.
3. design the components using drawing and other forming processes.

Suggested Books:		
Sr No	**Name of Book/ Authors/ Publisher**	**Year of Publication / Reprint**
1	Mechanical Working of Metals: Theory and Practice / Pergamon / John Noel Harris, first edition	2014
2	Manufacturing Engineering and Technology / Serope Kalpakjian, Steven R Schmid/Pearson India	2014
3	Mechanical Metallurgy/ Dieter/ Tata McGraw Hill	2012
4	DeGarmo's Materials and Processes in Manufacturing/ J T Black, Ronald A Kohser/ Wiley	2011

Department Elective Courses

Course Name	**:**	**Welding Technology**
Course Code	**:**	**MM 2201**
Credits	**:**	**02**
L T P	**:**	**2 0 0**

Course Objectives
At the end of this course the student will be able to understand, select and control appropriate welding process for industrial applications with emphasis on weld quality.

Total No. of Lectures-28

Lecture Wise Breakup		**Number of Lecture**
1	**Source and Heat Flow in Welding** Arc welding, type of welding arcs, role of electrode, polarity, arc stability, metal transfer, temperature distribution in welding, determination of HAZ, heat flow in weld.	5
2	**Welding Techniques** Various arc welding processes, resistance welding, electroslag and electro-gas welding, gas welding, solid state welding, explosive welding, electron beam welding, laser welding, thermit welding, ultrasonic welding, diffusion bonding, welding equipments and welding operations.	8
3	**Welding Metallurgy** Basic metallurgy of fusion, various zone in welding and their properties, solidification of weld pool, effects of welding parameters on microstructures of weld, pre-heat and post weld heat treatments, deoxidation of weld pool, composition control of weld deposit, welding of metals and non-metals weldability of steels, weldability tests, welding stresses.	10
4	**Weld Evaluation** Types of defects: inspection and their remedies.	4
5	**AWS Standards** AWS A5.1, AWS B1.10, AWS D1.1, AWS D1.5, AWS D1.9 etc.	1

Course Outcome:
Student will be able to: 1. understand the fundamental concepts of different welding processes. 2. analyze the metallographic changes during welding operations. 3. select the welding process for specific applications.

Suggested Books:		
Sr No	**Name of Book/ Authors/ Publisher**	**Author/Publisher**
1	Welding Technology / Bruce Stirling / Dhanapat Rai Publishing Company Pvt. Ltd.	2013
2	Welding Technology and Design / Radha Krishnan V M/ New Age International Pvt. Ltd.	2008
3	Welding Metallurgy /Sindo Kou/John Willed USA/ 2nd edition.	2003
4	Welding Engineering and Technology /RS Parmar/Khanna Publisher New, Delhi/ 2nd edition.	2002
5	Welding and Welding Technology/Richard Little/Tata McGraw Hill	2001

Course Name	**:**	**Additive Manufacturing**
Course Code	**:**	**MM 2202**
Credits	**:**	**02**
L T P	**:**	**2 0 0**

Course Objectives:

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

1. understand the basics of additive manufacturing/rapid prototyping and its applications in various fields.
2. categorize the different processes in rapid prototyping systems.
3. analyze the different properties and geometric issues relating to specific rapid prototyping applications.

Total No. of Lectures – 28

Lecture wise breakup		**Number of Lectures**
1.	**Introduction to Additive Manufacturing (AM)** General overview: Introduction to reverse engineering traditional manufacturing vis AM Computer Aided Design (CAD) and Manufacturing (CAM) and AM, different AM processes and relevant process physics AM process chain application level: direct processes- rapid prototyping, rapid tooling, rapid manufacturing; indirect processes, indirect prototyping, indirect tooling, indirect manufacturing.	8
2.	**Materials Science for AM** Discussion on different materials used of multiple materials, multifunctional and graded materials in AM role of solidification rate evolution of non-equilibrium structure, structure property relationship; grain structure and microstructure.	6
3.	**AM Technologies** Powder-based AM processes involving sintering and melting (selective laser sintering, shaping, electron beam melting, involvement), printing processes (droplet-based 3D), Solid-based AM processes- extrusion based fused deposition modeling object Stereolithography Micro- and nano-additive.	8
4.	**Process Selection Planning, Control for AM** Selection of AM technologies using decision methods, additive manufacturing process plan: strategies and post processing. monitoring and control of defects, transformation.	6

Course Outcomes:

Student will be able to:

1. select and use correct CAD formats in the manufacturing of 3D printing part.
2. understand the operating principles, capabilities, and limitations of liquid and solid based additive manufacturing system.
3. appreciate the operating principles, capabilities, and limitations of powder based additive manufacturing system.

Suggested Books:

Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping and Direct Digital Manufacturing/ I. Ian Gibson, David W Rosen, Brent Stucker/ Springer	2015
2	Laser-assisted Fabrication of Materials/ J D Majumdar and I Manna/ Springer Series in Material Science	2013
3	Numerical Modeling of the Additive Manufacturing (AM) Processes of Titanium Alloy/ Z Fan and Frank Liou / lnTech.	2012

4	Rapid Prototyping: Principles and Applications/ C K Chua, K F Leong and C S Lim/ 3rd Edition, World Scientific	2010
5	Understanding Additive Manufacturing: Rapid Prototyping, Rapid Tooling, Rapid Manufacturing, Andreas Gebhardt/ Hanser Publishers	2011
6	Laser-Induced Materials and Processes For Rapid Prototyping, L Lu, J Fuh and Y S Wong/ Kluwer Academic Press	2001

Course Name	**:**	**Polymer Technology**
Course Code	**:**	**MM 2203**
Credits	**:**	**02**
L T P	**:**	**2 0 0**

Course Objectives:

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

1. describe the properties of polymer and analyze electrical, thermal, and elastic behavior of polymers.
2. design of polymeric materials for given applications.

Total No. of Lectures – 28

Lecture wise breakup		**Number of Lectures**
1	**Introduction** Basic concept, classification, chemical bonding and molecular forces in polymers, thermoplastics and thermosets, molecular weight and its distribution determination (M_n to M_z), free radical polymerization, Ziegler-Natta polymerization, cationic & anionic polymerization, novolacs and resol: effect of the ratio of phenol to aldehyde on the nature and the property of the polymer.	2
2	**Processing Technique** Compounding and vulcanization, molding techniques: extrusion, injection molding, blow molding, compression molding.	3
3	**Polymer Fiber** Natural and synthetic fibers, criteria for fiber formation, testing and modification of fibers.	2
4	**Thermal Properties** Heat capacity, transition temperatures such as T_g and T_m, heat capacity of crystalline and amorphous polymers, thermal conductivity, thermal analysis of polymers (DTA, DSC, and TGA).	6
5	**Mechanical Properties** Stress-Strain behavior, effects of temperature on stress-strain behavior of polymer, macroscopic deformation, viscoelastic deformation, viscoelastic relaxation modulus, fracture of polymers, other mechanical properties, plastic deformation and its mechanism, deformation of elastomers.	7
6	**Dielectric Properties** Basic concepts, dielectric and relaxation of polymers, mechanism of relaxation, experimental methods to study dielectric properties of polymers, dielectric behavior of polyethylene, introduction to conducting polymers, discovery of polyacetylene, concept of doing and n-type, polarons and bipolarons, conduction mechanism, redox type polymers.	4
7	**Applications** Application of polymers in engineering and industry e.g. cancer therapy, nano filtration, electronics, drug delivery, agriculture, lubricants and nanopaints.	2
8	**High Temperature Polymer** High temperature polymers, crystalline polymers.	2

Course Outcomes:

Student will be able to:

1. describe the variation of properties of polymer by crystallinity and glass transition temperature
2. explain the relationship between polymer properties (thermal, dielectric, mechanical), polymer microstructure and molecular weight.
3. design polymeric materials for a specific application.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication /Reprint**
1	Polymer Science/ V R Gowarikar, N S Viswanathan & Jayadev Sreedhar/ New Age International Publishers/ 3rd edition	2019
2	Text book of polymer Science/ Fred W Billmeyer/ John Wiley and Sons/ 3rd edition	2007
3	Polymer Science and Technology/ R O Ebewele/ CRC press/ 3rd edition	2000

Course Name	**:**	**Materials Handling**
Course Code	**:**	**MM 2204**
Credits	**:**	**02**
L T P	**:**	**2 0 0**

Course Objectives:

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

1. design materials handling system.
2. understand the overall facilities planning process.
3. develop a systematic plant layout and know the environmental and economical aspects in facilities planning.

Total No. of Lectures – 28

Lecture wise breakup		**Number of Lectures**
1	**Introduction** Objective of material handling systems, material handling principles, material handling engineering survey, relationship of material handling to plant layout.	3
2	**Basic Material Handling Systems** Basic features of handling, types of material handling systems, various material handling considerations including combined handling, space for movements, analysis of handling methods, economical and technical considerations of handling equipments, cost analysis of material handling systems.	7
3	**Design of Hoists** Design of hoisting equipment likes: wire and hemp rope, welded and roller chains, design of ropes and pulleys, pulley systems, sprockets and drums, load handling attachments. design of hooks: forged hooks and eye hooks, girder design, crane grabs, grabbing attachments, design of arresting gear, design of conveyors: hydraulic and pneumatic conveyors.	12
4	**Methods to Minimize Cost of Material Handling** Maintenance of material handling equipment's, safety in handling, ergonomics of material handling equipment, current trends in material handling Computer Aided Systems for material handling, procedures for travel charting, numerical problems in optimum arrangement of various departments and shops under given constraints and to check their effectiveness.	6

Course Outcomes:

Student will be able to:

1. understand the selection procedure of materials handling system.
2. design of hoists like wire rope and conveyer etc.
3. analyze the current trends of materials handling by Computer Added System.

Suggested Books:

Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Aspects of Material handling/ K C Arora/ Laxmi Publication	2011
2	Operations Management/ PB Mahapatra / PHI	2010
3	Materials Handling Handbook /Kulwiec / Wiley	2009
4	Introduction to Material Handling. Ray/ New Age International Pvt. Ltd./ 2nd Edition	2008
5	Materials Handling Equipments/ M. Alexandrov/ MIR Publishers	1981

Course Name	**:**	**Ceramics for Strategic Applications**
Course Code	**:**	**MM 2205**
Credits	**:**	**02**
L T P	**:**	**2 0 0**

Course Objectives:

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

1. describe the basics of ceramic processing including sintering theory and grain growth.
2. relate the basics properties of advanced ceramic materials with their structure.

Total No. of Lectures – 28

Lecture wise breakup		**Number of Lectures**
1	**Powder Preparation** Physical methods (different techniques of grinding), chemical routes - coprecipitation, sol-gel, hydrothermal, combustion synthesis, high temperature reaction (solid state reaction).	5
2	**Basic Principles and Techniques of Consolidation and Shaping of Ceramics** Powder pressing- uniaxial, biaxial and cold isostatic and hot isostatic, injection moulding, slip casting, tape-casting, calendaring, multilayering.	4
3	**Sintering** Thermodynamics and kinetics of sintering, different mechanisms and development of microstructure (including microwave sintering).	6
4	**Electrical Behaviour** Insulating (dielectric, ferroelectric, piezoelectric, pyroelectric) semiconducting, conducting, superconducting and ionically conducting, specific materials and their applications.	3
5	**Magnetic Behaviour** Basic principles, materials and their applications.	2
6	**Transparent Ceramics** Coatings and films: preparation and applications.	2
7	**Porous Ceramics and Ceramic Membrane** Fabrication techniques and applications in separation technology.	2
8	**Applications of Ceramics** Bio-medical applications of ceramic materials, ceramics for energy and environment technologies (fuel cell, lithium battery, gas sensor and catalytic support).	4

Course Outcomes:

Student will be able to:

1. understand the thermodynamic and kinetics of ceramic processing.
2. develop the specific ceramic for various engineering applications.

Suggested Books:

Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Fundamental of Ceramics/ Michel W. Barsoum/ McGraw Hill International edition	2019
2	Modern Ceramic Engineering/ David. W. Richerson, Mercel Dekker/ NY	2019
3	Ceramic Processing and Sintering/ M. N. Rahman, Mercel Dekker/ CRC Press	2017
4	Handbook of Advanced Ceramics/ S. Somiya/ Academic Press	2003

Course Name	**:**	**Composite Materials and Mechanics**
Course Code	**:**	**MM 2206**
Credits	**:**	**02**
L T P	**:**	**2 0 0**

Course Objectives:

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

1. define property enhancement mechanisms, understand capabilities and limitations of existing materials and processes.
2. determine opportunities for improvement and select materials and processes to best suit specific applications.

Total No. of Lectures – 28

Lecture wise breakup		**Number of Lectures**
1	**Introduction** Composites and their classification and properties, reinforcement: glass fibers, boron fibers, carbon fibers, organic fibers, ceramic fibers, non-oxide fibers, comparison of different types of fibers., particulate composites, hybrid composites, long aligned fiber composites.	4
2	**Processing of Composites** Hand lay-up, pre preg processing, press molding, vacuum molding, filament winding, extrusion, pultrusion, liquid metal infiltration process, diffusion bonding and powder metallurgy methods, joining of composites, basic properties of GRP, CFRP, Al-B, Casting and Particulate composites.	6
3	**Failure/ Fracture of Composites:** Tensile strength, compressive strength, fractures modes in composites, maximum stress theory, maximum strain criterion, maximum work criterion, comparison of failure theories	5
4	**Micromechanics and Macromechanics of composites:** Methods for predicting elastic constants, thermal properties, and transverse stresses in fibrous composites, mechanics of load transfer, Elastic constant for Isotropic and Lamina, Analysis of Laminated composites.	8
5	**Properties and Applications:** Modulus, Strength, thermal characteristics, aging, fatigue, creep, transport properties, matrix connectivity, aerospace application, structural, defense biomedical application, machine tools, automobiles applications.	5

Course Outcomes:

Student will be able to:

1. understand the fundamentals of composite materials for different applications.
2. select the processing parameters for the development of composite materials for specific applications.
3. analysis and resolve the problems related to fracture of composites and environmental degradation of composites.

Suggested Books:

Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Composite materials/Chawla K.K/ Springer-Verlag	2019
2	An Introduction to Composite Materials/ CLYNE and HULL/Cambridge University Press	2019
3	Composite Materials Hand Book / Mel M.Schwartz / McGraw Hill	2001
4	Composite materials: Engineering and Science /Mathews and Rawlings R.D/Chapman and Hall, London	1999

Course Name	**:**	**Industrial Tribology**
Course Code	**:**	**MM 2207**
Credits	**:**	**02**
LTP	**:**	**2 0 0**

Course Objectives
At the end of the course, the student will be able to: 1. understand various modes of friction and wear. 2. study the effect of lubricant and their application in different operating conditions.

Total No. of Lectures – 28

Lecture wise breakup		**No. of Lectures**
1	**Friction** Fundamental of engineering surfaces, industrial significance of tribology, friction theories, rules of solid-solid contact, liquid mediated contact, measurement methods of friction, sliding/rolling friction, friction of materials: friction of metals and alloys, friction of ceramics, friction of polymer, friction of solid lubricants, friction instability.	5
2	**Interface Temperature of Sliding Surfaces** Thermal analysis: fundamental heat conduction solutions, high contact-stress conditions (single asperity contact), low stress conditions (multi asperity contact); interface temperature measurements: thermocouple and thin film temperature sensors, radiation detection techniques, metallographic techniques.	4
3	**Wear** Types of wear mechanism: adhesive wear, abrasive wear, fatigue wear, impact wear, corrosive wear, fretting wear, and wear debris: plate-shaped particles, ribbon-shaped particles, spherical particles, irregular particles, testing methods and standards: ASTM G-65 for dry sand/ rubber wheel abrasion test, ASTM G105 for wet sand/ rubber wheel abrasion test, ASTM G132 for pin abrasion test, ASTM G75 for slurry abrasivity test.	7
4	**Lubrication and Lubricants** Importance of lubrication, boundary lubrication, mixed lubrication, full fluid film lubrication; hydrodynamic, elastohydrodynamic lubrication, types & properties of lubricants, lubricants additives.	5
5	**Case Studies** Tribology in gearbox, transmission and transfer case, tribology of friction disk, tribology of internal combustion engines, tribology of gas turbine engine, tribology of hydraulic pump, bio-tribology, tribology in space.	7

Course Outcomes:
Student will be able to: 1. explain the friction and wear mechanism in different industrial applications. 2. suggest different suitable materials for industrial applications.

Suggested books		
S. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Tribology: Friction and Wear of Engineering Materials / Ian Hutchings and Philip Shipway/ Butterworth-Heinemann.	2017
2	Tribology for Scientists and Engineers: From Basics to Advanced Concepts/ Pradeep L. Menezes, Satish V. Kailas, Michael R. Lovell/ Publisher: Springer-Verlag New York.	2013
3	Industrial Tribology: Tribosystems, Friction, Wear and Surface Engineering, Lubrication/ Theo Mang, Kirsten Bobzin, Thorsten Bartels/ Wiley-VCH.	2010

Course Name	**:**	**Science and Technology of Sintering**
Course Code	**:**	**MM 2208**
Credits	**:**	**02**
LTP	**:**	**2 0 0**

Course Objectives
At the end of the course the student will be able to: 1. understand the different stages of sintering. 2. understand various sintering technique and parameters for different materials.

Total No. of Lectures – 28

Lecture wise breakup		**No. of Lectures**
1	**Thermodynamic of Sintering** Sintering process, surface energy, sintering stress, atomistic changes in sintering, sintering changes prior to interfacial energy equilibrium, microstructure gradients, chemical and strain gradients, thermodynamics stages and mechanism of mass flow, microstructure links to sintering thermodynamics.	6
2	**Kinetics and Mechanism of Densification** Solid state sintering, viscous sintering, liquid phase sintering: grain growth in a liquid matrix, densification during liquid phase sintering, pressure-assisted sintering, electric-assisted sintering, effect of materials and process variables.	6
3	**Advanced Sintering Processes** Atmosphere sintering, vacuum sintering, microwave sintering, fundamentals and application of field assisted sintering, photonic sintering.	9
4	**Sintering of Advanced Materials** Sintering of aluminum and its alloy, sintering of titanium and its alloy, sintering of refractory metals, sintering of ultrahard materials, sintering of thin-film/constrained sintering.	7

Course Outcomes:
Student will be able to: 1. explain the fundamentals of sintering techniques. 2. suggest sintering parameters to tailor the microstructure and properties of materials for specific applications.

Suggested books		
S. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Sintering Technology/German, Randall M, Messing, Gary L, Cornwall, Robert G/Taylor & Francis	2020
2	Sintering of Advanced Materials/ Zhigang Zak Fang/ Woodhead Publishing	2010
3	Advanced Science and Technology of Sintering/ Yuri Kornyushin, Biljana D. Stojanovic, Valery V. Skorokhod, Maria Vesna Nikolic/ Springer US.	1999

Course Name	**:**	**Thin Film Technology**
Course Code	**:**	**MM 2209**
Credits	**:**	**02**
L T P	**:**	**2 0 0**

Course Objectives
At the end of the course the student will be able to: 1. understand the concepts for thin film coating starting from source materials to transportation and depositions. 2. apply the related methods and technology for deposition of thin films. 3. analyze and characterize thin film coatings in terms of its optical, electrical and mechanical properties.

Total No. of Lectures – 28

Lecture wise breakup		**Number of Lectures**
1	**Introduction** Hertz Knudsen equation; mass evaporation rate; Knudsen cell, directional distribution of evaporating species evaporation of elements, compounds, alloys. kinetics and diffusion, nucleation and growth, film formation, growth modes.	7
2	**Deposition Techniques** Physical vapor deposition, chemical vapor deposition - reaction chemistry and thermodynamics of PVD, CVD methods of producing thin films: PVD, CVD, sputtering, epitaxial films.	7
3	**Characterization of Thin Films** Optical methods for measuring film thickness; mechanical techniques for measuring film thickness; structural characterization using SEM, TEM; chemical characterization using EDX, AES, XPS etc.	6
4	**Applications for Thin Films** Hard coatings, corrosion resistance coatings, high temperature resistance coatings, transparent conducting coating, optical coating, sensors, thin film transistors in active-matrix liquid crystal displays, organic based thin film transistors etc.	8

Course Outcomes:
Students will be able to: 1. understand the general concepts and techniques for thin film deposition. 2. perform thin film thickness measurement and microstructural & chemical analysis for an engineering application.

Suggested books		
S. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	The Materials Science of Thin Films / M. Ohring / Academic Press /2nd edition.	2005
2	Handbook of Thin Film Materials: Deposition and processing of thin films / H. Nalwa/ Academic Press / 1st edition.	2001
3	Thin Film Deposition: Principles and Practice/ D. L. Smith / McGraw-Hill/ 1st edition.	1995

Course Name	**:**	**Nanomaterials for Optoelectronic Applications**
Course Code	**:**	**MM 2210**
Credits	**:**	**02**
L T P	**:**	**2 0 0**

Course Objectives
At the end of the course the student will be able to: 1. impart knowledge of the fundamental concepts and properties of nanomaterials and nanotechnology. 2. apply the fundamental concepts of nanomaterials for the optoelectronics applications.

Total No. of Lectures – 28

Lecture wise breakup		**Number of Lectures**
1	**Introduction to Nanomaterials** Introduction to miniaturization, fundamentals of nanoscience and nanotechnology, bulk to nano transition, classification: 0D, 1D, 2D, 3D nanomaterials quantum wells, quantum wires, and quantum dots, carbon nanostructures, electronic and magnetic properties at nano level, nanostructured materials.	7
2	**Synthesis and Preparation of Nanomaterials** Bottom-up and top-down approaches for the synthesis of nanomaterials, mechanical alloying, chemical routes, compaction of nano-powders, preparation of bulk nano-crystalline materials.	7
3	**Energy Band and Density of States** Energy band in solids, density of states, density of states in nanostructured materials, occupation probability and carrier concentrations, quasi fermi levels, band gap engineering in nanomaterials, quantum confinement, rates of emission and absorption, condition for amplification by stimulated emission, the laser amplifier.	8
4	**Nanostructured Materials for Optoelectronic Devices** Light-emitting diodes (LEDs), laser diodes, single-electron transistors, photonic crystals, photodetectors, solar cells etc.	6

Course Outcomes:
Students will be able to: 1. understand the properties, structure and classification of nanomaterials. 2. understand and account for different approaches used for synthesis of nanomaterials. 3. use nanomaterials for optoelectronic application.

Suggested Books		
S. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Nanomaterials for Optoelectronic Applications / S. Mohd., A K Kaushik, S Al Faify / Academic Press /1st edition.	2021
2	Magnetic Nanomaterials: Fundamentals, Synthesis and Applications / Y. Hou, D. J. Sellmyer / John Wiley & Sons / 1st edition.	2017
3	Nanomagnetism: Fundamentals and Applications / C Binns / Elsevier / 1st edition.	2014
4	Nanostructured Materials: Processing, Properties and Applications/ C.C Koch/ William Andrew/ 2nd edition.	2006
5	Introduction to Nanotechnology / C.P Poole, F.J., Owens / John Wiley and sons / 1st edition.	2003

Course Name	**:**	**Nanomaterials for Magnetic Applications**
Course Code	**:**	**MM 2211**
Credits	**:**	**02**
L T P	**:**	**2 0 0**

Course Objectives
At the end of the course the student will be able to: 1. impart knowledge of the fundamental concepts and properties of nanomaterials and nanotechnology. 2. apply the fundamental concepts of nanomaterials for the magnetic applications.

Total No. of Lectures – 28

Lecture wise breakup		**Number of Lectures**
1	**Introduction to Nanomaterials** Introduction to miniaturization, fundamentals of nanoscience and nanotechnology, bulk to nano transition, classification: 0D, 1D, 2D, 3D nanomaterials quantum wells, quantum wires, and quantum dots, carbon nanostructures, electronic and magnetic properties at nano level, nanostructured materials.	8
2	**Synthesis and Preparation of Nanomaterials** Bottom-up and top-down approaches for the synthesis of nanomaterials, mechanical alloying, chemical routes, compaction of nano-powders, preparation of bulk nano-crystalline materials.	7
3	**Magnetism in Nanomaterials** Orbital and spin-permanent magnetic moment of atoms, diamagnetism, paramagnetism, ferro, anti-ferro and ferri-magnetism, ferrites, magnetic hysteresis, soft and hard magnetic materials, magnetism in nanomaterials, super-paramagnetism	6
4	**Nanostructured Materials for Magnetic Applications** Spintronic and memory devices, multi-ferroic materials, catalysis, and environmental purification, superconductors, sensors, drug delivery etc.	7

Course Outcomes:
Students will be able to: 1. understand the properties, structure and classification of nanomaterials. 2. understand and account for different approaches used for synthesis of nanomaterials. 3. use nanomaterials for magnetic application.

Suggested Books		
S. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Magnetic Nanomaterials: Fundamentals, Synthesis and Applications / Y Hou, D J Sellmyer / John Wiley & Sons / 1st edition	2017
2	Nanomagnetism: Fundamentals and Applications / C Binns / Elsevier / 1st edition	2014
3	Nanomaterials and Nanochemistry / C Brechignac, P Houdy, M Lahman / Springer /1st edition	2006
4	Introduction to Nanotechnology / C P Poole, F J Owens / John Wiley and sons / 1st edition	2003

Course Name	**:**	**Powder Metallurgy**
Course Code	**:**	**MM 2212**
Credits	**:**	**02**
L T P	**:**	**2 0 0**

Course Objectives:

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

1. understand the characteristics and theory of compaction of metal powders.
2. understand the theory of sintering for application to manufacture service components.

Total No. of Lectures – 28

Lecture wise breakup		**Number of Lectures**
1	**Introduction** Potential and prospects of powder metallurgy, problems in industries, advantages of powder metallurgy.	1
2	**Powder Manufacture and Conditioning** Ball milling, atomization, shotting chemical methods, condensation, thermal decomposition, carbonyl, reduction by gas hydride, dehydride process, electro deposition, precipitation from aqueous solution and fused salts hydrometallurgical method. electrolysis and automization processes, types of equipment, factors affecting these processes, examples of powders produced by these methods, applications powder conditioning, blending and mixing, types of equipment.	7
3	**Characteristics and Testing of Metal Powders** Particle size and its measurement, microscopic analysis: sedimentation, elutriation, permeability, adsorption methods and resistivity methods: particle shape, classifications, microstructure, specific surface area, apparent and tap density, green density, green strength, sintered compact density, porosity, shrinkage.	3
4	**Powder Compaction** Mechanical, thermal and thermo -mechanical compacting processes. presses used for compaction die design and tools, roll compaction, isostatic pressing, advantages and limitations of these methods, pressureless compaction such as slip casting and slurry casting, pressure compaction lubrication, single ended and double ended compaction.	7
5	**Theories of Sintering** Sintering mechanism, roll of diffusion, recrystallization, pore migration, pore growth and coalescence, liquid phase sintering and related processes, effect of compacting pressure, sintering temperature and time on properties of sinter, type of sintering furnaces, sintering atmospheres.	6
6	**Manufacturing and Application of Important P/M Components** Porous bearing, electrical contact materials, metallic filters, cemented carbides, magnets, friction materials major applications in aerospace and automobile industries. self-lubrication and other types, properties, applications. sintered friction materials-clutches, brake linings, tool materials- cemented carbides, oxide ceramics, cermets dispersion strengthened materials, MIM process and products.	4

Course Outcomes:

Student will be able to:

1. understand the manufacturing and characterization of powders.
2. apply compaction and sintering theory in powder metallurgy processes.
3. develop and analyze the process variable for service components.

Suggested Books:

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Advances in Powder Metallurgy: Properties, Processing and Applications / Isaac Chang, Yuyuan Zhao / Elsevier	2013
2	Powder Metallurgy: An Advanced Technique of Processing Engineering Materials / B. K. Datta / PHI Learning Pvt. Ltd.	2011
3	Powder Metallurgy: Science, Technology and Application / Angelo & Subramania / PHI Learning Pvt. Ltd.	2009
4	Powder Metallurgy Technology / G. S. Upadhyaya / Cambridge Int Science Publishing	1997

Course Name	**:**	**Fundamentals of Electrochemistry**
Course Code	**:**	**MM 2213**
Credits	**:**	**02**
L T P	**:**	**2 0 0**

Course Objectives:

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

1. understand the basics of electrochemical processes under standard and non-standard conditions.
2. understand and apply the thermodynamic concepts related to electrochemical cells.
3. apply the principles of electrochemical techniques.

Total No. of Lectures – 28

Lecture wise breakup		**Number of Lectures**
1	**Introduction** Electric charge, charges at rest, capacitance and conductance, mobilities, electrical circuits, derivation of Nernst equation, cell emf, sign conventions, electrochemical series and its applications.	7
2	**Transport** Transport number and its determination by Hittorff's and moving boundary method, effect of temperature and concentration, ionic mobility and ionic conductance, Kohlrausch's law and its applications.	7
3	**Activity: Restlessness in Chemical Species** Theory of strong electrolytes and Debye Huckel Onsager theory, verification of Onsager equation, Wein effect and Debye–Falkenhagen effect, ionic strength, activity and activity coefficients of strong electrolytes.	7
4	**Electrochemical and Electrode Reactions** Applications of conductivity measurements, conductometric titrations, chemical cells and concentration cells with and without transference, liquid junction potential.	7

Course Outcomes:

Student will be able to:

1. understand the basic principles electrochemistry.
2. explain various methods for the determination of transport number.
3. apply the concepts of electrochemical potential and electrochemical processes.

Suggested Books:

Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	An Introduction to electrochemistry / S Glasstone / Maurice Press/10th edition	2011
2	Electrochemical Methods: Fundamentals and Applications / Allen J Bard, Larry R Faulkner / Wiley/2nd edition	2000

Course Name	**:**	**Electrochemical Processes for Industrials Applications**
Course Code	**:**	**MM 2214**
Credits	**:**	**02**
L T P	**:**	**2 0 0**

Course Objectives:

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

1. cover the of technical aspects of electrochemistry.
2. explain the importance of electrocatalytic processes to meet future energy demands for environmental and societal implications.

Total No. of Lectures – 28

Lecture wise breakup		**Number of Lectures**
1	**Fundamental Concepts** Electron transfer, mass transport, the interplay of electron transfer and mass transport control, adsorption, electrocatalysis, phase formation in electrode reactions, chemical reactions, the properties of electrolyte solutions, assessment of cell voltage, electrochemistry at surfaces on open circuit	7
2	**Electrochemical Engineering** General considerations, performance and figures of merit, electrolysis parameters, principles of cell design, the additional technology of electrolytic processes, typical-cell designs, laboratory data and scale-up.	7
3	**Batteries and Fuel Cells** Battery characteristics, battery specifications, evaluation of battery performance, battery components, present battery systems, batteries under development, fuel cells.	7
4	**Electrochemical Sensors and Monitoring Techniques** Electrochemical procedures, polarography to anodic stripping voltammetry, Ion-selective electrodes, portable and on-line devices, electrochemical biosensors, miscellaneous.	7

Course Outcomes:

Student will be able to:

1. understand fundamental principles of electrochemical energy conversion systems in electrochemical phenomena.
2. apply the knowledge of electrochemistry in different applications

Suggested Books:

Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Non-Conventional Energy Resources/ B H Khan/ McGraw Hill Education Private Limited/ 3rd edition.	2016
2	Electrochemical Energy Advanced Materials and Technologies/ Jiang, San Ping Shen, Pei Kang Sun, Xueliang Wang, Chao-Yang Zhang, Jiujun / Wiley-ISTE/ 1st edition.	2015
3	Electrochemical Methods: Fundamentals and Applications/ Allen J Bard, Larry R Faulkner/ Wiley/ 2nd edition.	2000
4	Industrial Electrochemistry/ Derek Pletcher/ Springer Netherlands/ 3rd edition.	1993

Course Name	**:**	**Spectroscopy and XRD**
Course Code	**:**	**MM 2215**
Credits	**:**	**02**
L T P	**:**	**2 0 0**

Course Objectives
At the end of the course the student will be able to: 1. understand concept of different spectroscopy techniques. 2. analyze the structure, purity and chemical composition of materials.

Total No. of Lectures – 28

Lecture wise breakup		**Number of Lectures**
1	**Introduction to Spectral Methods** Molecular and atomic spectroscopy-interaction of electromagnetic radiation with matter-Energy levels in atoms and molecules, fluorescence, phosphorescence and chemo luminescence-Beer-Lambert law.	6
2	**UV-Visible and Photoelectron Spectroscopy** Electromagnetic spectrum, laws of absorption of light, deviation from Beer-Lambert's Law, photoelectric effect, UV photoelectron spectroscopy (UPES), X-ray photoelectron spectroscopy (XPES), electron binding energy.	5
3	**Fourier-Transform Infrared Spectroscopy (FTIR) and Raman Spectroscopy** Basic principle, instrumentation configuration, data interpretation and analysis, and Polarization modulation-infrared reflection-adsorption spectroscopy (PM-IRRAS).	4
4	**X-Ray Diffraction** Bragg's Law, X-ray spectroscopy, diffraction methods; X-ray scattering by electron and atom, structure factor calculation, multiplicity factor, Lorentz factor, absorption factor, temperature factor, intensities of powder pattern lines, experimental methods: Laue methods, Debye-Scherrer method, rotation crystal method, structure determination: single crystal orientation determination, crystallite size determination, indexing patterns of cubic and non-cubic crystals, chemical analysis: phase identification, energy dispersion, microanalysis, residual stress measurements.	13

Course Outcomes:
Students will be able to: 1. analyze the structure, purity, and interpret spectroscopic data collected by the different techniques. 2. apply the diffraction methods and interpret the assigned X-ray diffraction pattern.

Suggested Books		
S. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Principles of Instrumental Analysis / D A Skoog, F J Holler, S R Crouch / Cengage Learning India / 7th edition	2020
2	Organic Spectroscopy / W Kemp / Red Globe Press / 3rd edition	2019
3	Spectroscopy of Organic Compounds / P S Kalsi / New Age International /6th edition	2007
4	Elements of X-Ray Diffraction / B D Cullity, S R Stock / Pearson / 3rd edition	2001

Course Name	**:**	**High Temperature Corrosion**
Course Code	**:**	**MM 2216**
Credits	**:**	**02**
L T P	**:**	**2 0 0**

Course Objectives
At the end of the course the student will be able to explain the oxidation process in metals/alloys at high temperatures and the oxidation mechanism in metals/alloys at high temperatures.

Total No. of Lecture-28

Lecture wise Breakup		**Number of Lectures**
1.	**Introduction** Oxidation, low temperature vs high temperature corrosion, thermodynamics of gas/metal reaction stability of oxides/sulphides, Pilling-Bedworth ratio, Ellingham diagrams, creep resistance of materials.	8
2.	**Oxidation Mechanism** Mechanism of oxidation, Wagner's theory of oxidation, oxidation kinetics-linear, parabolic, cubic, logarithmic laws, scale spallation, defects in oxides.	7
3.	**Oxidation Processes and their Control** General oxidation, cycle oxidation, selective oxidation, internal oxidation, breakaway and catastrophic oxidation, effect of water vapour on oxidation, hot-corrosion, effect of alloying elements on hot corrosion, sulphidation, carburization, control of oxidation by alloy additions.	8
4.	**High Temperature Alloys** Iron, nickel and cobalt base super alloys, materials used in power plants, gas turbines, petrochemical plants etc.	5

Course Outcomes:
Student will be able to: 1. understand the oxidation behavior of different metals/alloys at high temperatures. 2. apply the oxidation mechanism for high temperature applications.

Suggested Books		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1.	High Temperature Oxidation and Corrosion of Metals / David Young/ Elsevier Science/ 2nd edition	2016
2.	High Temperature Corrosion/ Per Kofstad/ Elsevier Applied Science/ 2nd edition	1998

Suggested books		
S. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Materials Science and Engineering an Introduction/William D Callister, Jr., David G. Rethwish/ Wiley	2018
2	Handbook of Materials Failure Analysis with Case Studies from the Aerospace and Automotive Industries/Abdel Salam Hamdy Makhlouf, Mahmood Aliofkhazraei/ Elsevier	2016
3	Failure Analysis of Engineering Structures: Methodology and Case Histories/V Ramachandran, A.C. Raghuram, RV Krishnan, and SK Bhaumik/ASM International	2005
4	Deformation and Fracture Mechanics of Engineering Materials/R. W. Hertzberg/ John Wiley & Sons.	1996

Course Name	**:**	**Non-Destructive Testing**
Course Code	**:**	**MM 2401**
Credits	**:**	**4**
L T P	**:**	**3 1 0**

Course Objectives

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

1. understand basics principles of Non-Destructive Testing methods.
2. examine the components/ parts for real time applications.

Total No. of Lectures-42

Lecture wise Breakup		**Number of Lectures**
1	**Overview** Motivation, capabilities, limitations of NDT methods, variables in inspection and statistical issues.	3
2	**Surface Methods** Visual inspection, liquid, dye penetrate testing, basic principle, types of dye and methods of application, magnetic particle inspection, basic theory of magnetism, limitations, applications.	7
3	**Electro-magnetic and Acoustical Methods** Maxwell's equations, magnetic flux leakage, eddy current, low frequency eddy current, pulsed eddy current, ultrasonic NDT principles, different types of wave modes, physics of wave generation, reception, interactions and propagation, test method, distance and area calibration, weld inspection by ultrasonic testing, new methods using guided waves, resonance and low frequency methods.	12
4	**Radiographic Methods** Radiography-X-rays and their properties, X-ray generation, X-ray absorption and atomic scattering image collection, high quality films.	6
5	**Thermal Methods** Principles of thermography and approaches in NDT, Sources and detectors, capabilities and limitations, measurement of diffusivity and wall thickness.	6
6	**Optical Methods** Principles of Stereography and holography, applications in NDT.	4
7	**Applications** Nuclear industry, aerospace industry, transportation industry, process industry.	4

Course Outcome:

Student will be able to:

1. apply the concepts of NDT in selection of process for specific applications.
2. analyze the soundness of parts/components using NDT.

Suggested Books:

Sr No	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	NDT Handbooks Vol 1-17, ASNT Press, OH, USA	2012
2	Introduction to NDT: A Training Guide / Paul E Mix / John Wiley	2005
3	Nondestructive Evaluation - Theory, Techniques, and Applications/ P J Shull/ Marcell Decker Inc.	2002
4	Practical Non-Destructive Testing / Baldev Raj, T Jayakumar / Woodhead Publishing Ltd	2002
5	Non-Destructive Evaluation - A Tool in Design, Manufacturing and Service/ D E Bray and R K Stanley/ CRC Press	1996

Course Name	**:**	**Materials Joining Techniques**
Course Code	**:**	**MM 2402**
Credits	**:**	**04**
LTP	**:**	**3 0 2**

Course Objective:

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

1. explain various process of welding, brazing and soldering,
2. apply the fundamental knowledge to design fillers.
3. develop joint and analysis capability for sustaining joint in service.

Total Lectures: 42

Lecture wise breakup		**No. of Lectures**
1	**Introduction** Process introduction, industrial relevance, Welding arcs and stability, brazing vs soldering, comparison of brazing and soldering, Advantages and limitations of brazing, Mechanics of brazing	5
2	**Welding Techniques** Various arc welding processes, Resistance welding, Electroslag and electrogas welding, solid state welding, explosive welding, electron beam welding, laser welding, thermit welding, ultrasonic welding, diffusion bonding, welding equipments and welding operations, Adhesion bonding, surfacing and thermal spraying.	10
3	**CHARACTERISTICS OF JOINTS** Adhesion, wetting, spreading, capillary attraction, ceramic metal interface formation and reaction products, Metallurgical reactions, various zone at brazing interface, Alloying, Hydrogen, sulphur and Phosphorous embrittlements, stress cracking, filler-metal flow, base metal and filler metal characteristics, relative ease of brazing and soldering	7
4	**BRAZING AND SOLDERING TECHNIQUES** Surface preparation, joint design and clearance, Torch brazing, Furnace brazing, Induction brazing, dip brazing, resistance brazing, infrared brazing, laser brazing, exothermic brazing, microwave brazing, Controlled atmosphere brazing, Diffusion brazing, silver soldering, soft soldering and electrical soldering	8
5	**WELDING, BRAZING AND SOLDERING FILLERS** Introduction and synthesis of Silver –alloys (Ag-Cu-Sn, Ag-Al.Sn), (Al-Si-Fe-Zn-Sn), brazing and soldering fluxes, flux coatings, Welding electrodes and electrode coating.	6
6	**CASE STUDIES, TESTING AND EVALUATION**	6

Lab Experiments	**No. of Hours**
Lab component comprises project work assigned by the course coordinator.	28

Course Outcome:

Student will be able to:

1. explain various process of brazing and soldering
2. analysis and interpret the brazing and soldering joints
3. capability for recommendation of new filler for industrials use like Al-based, Ag-based

Suggested Books:

S. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Brazing and soldering/ Rechad lofting/ Crowood Press LTD	2014
2	Industrial brazing practices,	2013
3	Brazing/ second edi, Mel Schwartz/ ASM International	2003
4	Welding Metallurgy//SindoKou/JohnWilleyUSA/ 2nd edition	2003
5	Welding Engineering and Technology 2nd Edition/ RSParmar/ KhannaPublisherNew, Delhi,	2002
6	Welding and Welding Technology/ Richard Little/ Tata McGraw Hill,.	2001

Course Name	**:**	**High Entropy Alloys**
Course Code	**:**	**MM 2403**
Credits	**:**	**04**
L T P	**:**	**3 1 0**

Course Objectives
At the end of the course the student will be able to explain all aspects of high-entropy alloys including formation rules, processing route, physical metallurgy, mechanical behavior, prediction of the structure.

Total No. of Lecture-42

Lecture wise Breakup		**Number of Lectures**
1.	**Introduction** Basic concept, Four core effects of High Entropy Alloys (HEAs), Equiatomic HEAs and non equiatomic HEAs	5
2.	**Solid Solution Phases and their Microstructure** Solid Solution with BCC, FCC, and BCC & FCC structure in equiatomic and nonequiatomic HEAs, Microstructure of HEAs, Thermal stability of HEAs	7
3.	**Synthesis and Processing** Liquid metallurgy route, Additive manufacturing, Solid state processing route	7
4.	**Physical Metallurgy High Entropy Alloys** Four core effects of HEAs, phase transformation in HEAs, defects in HEAs	6
5.	**Mechanical Properties of High Entropy Alloys** Hardness, tensile and compressive properties	5
6.	**Degradation of High Entropy Alloys** Wear behaviour, electrochemical behaviour, oxidation and thermal behaviour,	6
7.	**Potential Application and Prospects of High Entropy Alloys** High entropy superalloys, refractory high entropy alloys, application of HEAs in automobile industries, aerospace, hydrogen storage etc	6

Course Outcomes:
Student will be able to: 1. comprehensive understanding on the current status of HEAs. 2. understand the microstructure property correlations in HEAs in terms of structural and functional properties.

Suggested Books		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1.	High Entropy Alloy / B.S. Murty, Jien Wei Yeh, S Ranganathan, P P Bhattacharjee/ Elsevier Science/ 2nd edition	2019
2.	High Entropy Alloys: Innovations, Advances, and Applications/ T.S. Srivatsan, Manoj Gupta/ CRC Press/ 1st edition	2020
3.	High-Entropy Alloys: Fundamentals and Applications/ Michael C. GaoJien-Wei YehPeter K. LiawYong Zhang/ Springer/ 1st edition	2016

Course Name	**:**	**Advance Engineering Materials**
Course Code	**:**	**MM 2404**
Credits	**:**	**04**
L T P	**:**	**3 1 0**

Course Objectives:

The student will be able to apply the fundamentals of selection of materials for practical applications. To apply concepts for failure analysis of engineering applications. To correlate properties of materials with their structure.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**Introduction and Motivation for Materials Selection** Properties of Materials, Classification and parameter for the material selection, motivationfor materials selection	2
2	**Cost Basis for Selection** Cost effectiveness and value analysis / Analysis of cost	2
3	**Establishment of Service Requirements and Failure analysis** Selection and design in relation to anticipated service, Cause of failure in service,Mechanism of failure, Corrosion	4
4	**Specifications and Quality Control** Roll of standard specification, inspection and quality control	4
5	**Selection for Mechanical Properties** Strength, toughness, stiffness, fatigue, high temperature resistance and Creep resistance	7
6	**Selection for Surface Durability** Wear and abrasion resistance, corrosion resistance.	4
7	**Electrical Materials** Selection for electrical, magnetic properties	4
8	**Advanced Materials** Smart materials, Intelligent materials, Super Alloys	5
9	**Co-Relation**-Relation between Materials selection and Materials processing, Formalization of selection procedures	3
10	**Case Studies in Material Selections** Aerospace, Ship, Engine and Power generation, Automobile, Bearings, springs, Gears,Tools	7

Course Outcomes:

The students will be able to:

1. **s**pecify performance requirements of a desired material and the process for making it, in the context of a given application.
2. to analyze quantitatively the Performance Efficiency relationships for an article.

Suggested Books:

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

Course Name	**:**	**Emerging Materials for Energy Harvesting**
Course Code	**:**	**MM 2405**
Credits	**:**	**04**
L T P	**:**	**3 1 0**

Course Objectives
At the end of this course, student will be able to: 1. impart knowledge about the basics and properties relevant to different energy materials. 2. apply the fundamental concepts of materials for applications in energy and its sustainability.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**ELECTRONIC MATERIALS** Energy band in solids, Density of states, p-n junctions, metal-semiconductor contacts, bipolar junction transistors, MOSFETs, III-V and II-VI semiconductors, band gap engineering, metal oxides, carbon nanotubes and 2D semiconductors, Piezoelectric materials; piezoelectrics for energy harvesting.	8
2	**SPINTRONICS** Wide band gap semiconductor, dilute magnetic semiconductor, half-metallic materials, basic mechanism of spin polarization, application of spintronics device such as spin LEDs, spin transistors, spin injection contacts.	7
3	**DIELECTRIC MATERIALS FOR ENERGY STORAGE CAPACITORS** Introduction, dielectric constants and polarization, linear dielectric materials, capacitors; Polarization mechanisms; non-linear dielectrics, pyro-, piezo-, and ferro-electric properties, hysterisis and ferroelectric domains, key parameters for evaluating energy storage performance; stored and recoverable energy density, energy storage efficiency, dielectric breakdown field, discharge time, applications of energy storage capacitors.	10
4	**MULTIFERROIC MATERIALS** Origin of magnetic ordering in the oxide materials, origin of ferroic in electric diode ordering in oxide materials, coupling of magnetic and electric dipole ordering, possible materials and their engineering for multiferroic properties, applications of multiferroic materials.	8
5	**OPTICAL MATERIALS** Optical properties of materials: optical constants, index of refraction, absorbance, reflectivity, transmissivity, Hagen-Rubens relation; atomistic theory, rates of emission and absorption, Condition for amplification by stimulated emission, the laser amplifier, lasers, light emitting diodes (LEDs), OLEDs, integrated optoelectronics, modulators, switches.	9

Lab Experiments	**No. of Turns**
Lab component comprises project work assigned by the course coordinator.	28 Hrs

Course Outcomes
The students will be able to 1. design and tuning of materials for energy efficiency. 2. achieve improved performance in electronic and optoelectronic devices.

Suggested books:		
S. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Ferroelectric Materials for Energy Harvesting and Storage/ D. Maurya A. Pramanick, D. Viehland/ Woodhead Publishing	2020
2	Modern Piezoelectric Energy-Harvesting Materials/ R C. Bowen, R., Y.V. Topolov, H.A. Kim, / Springer	2016
3	Materials in Energy Conversion, Harvesting, and Storage/ Kathy Lu/ John Wiley & Sons, Inc.	2014

Course Name	**:**	**Non-Conventional Energy Resources**
Course Code	**:**	**MM 2406**
Credits	**:**	**04**
L T P	**:**	**3 1 0**

Course Objectives:

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

1. study working principles of non-conventional energy and their utilities.
2. describe the environmental aspects of non-conventional energy resources in comparison with various conventional energy systems, their prospects and limitations.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**Fundamentals of Energy Science and Technology** Introduction, energy, economy and social development, oil crisis, classification of energy sources, consumption trend of primary energy resources, importance of non-conventional energy sources, energy chain.	2
2	**Solar Energy** Energy Scenario, overview of solar energy conversion devices and applications, physics of propagation of solar radiation from the sun to earth, Fundamentals of solar PV cells, principles and performance analysis, modules, arrays, theoretical maximum power generation from PV cells, Applications: Solar Refrigeration, Passive architecture, solar distillation, and emerging technologies.	10
3	**Wind Energy** Introduction, Origin of Winds, Nature of Winds, Wind Turbine Siting, Major Applications of Wind Power, Basics of Fluid Mechanics, Wind Turbine Aerodynamics, Wind Turbine Types and their Construction, Wind Energy Conversion Systems (WECS), Wind–Diesel Hybrid System, Effects of Wind Speed and Grid Condition (System Integration), Wind Energy Storage, Environmental Aspects, Wind Energy Program in India.	10
4	**Emerging Technologies** Introduction, Fuel Cell, Hydrogen as Energy Carrier, Battery technology.	12
5	**Miscellaneous Non-Conventional Energy Technologies** Introduction, Magneto Hydrodynamic Power Conversion, Thermoelectric Power Conversion, Thermionic Power Conversion.	8

Course Outcomes:

Student will be able to:

4. importance and scope of non-conventional and alternate energy resources.
5. understand and explain, in general terms, how solar and wind power work.
6. understand the benefits and disadvantages of using non-conventional energy resources.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Wind Power Technology/ Joshua Earnest/ PHI Learning Pvt. Ltd./ 3rd edition.	2019
2	Non-Conventional Energy Resources/ B.H. Khan/ McGraw Hill Education (India) Private Limited/ 3rd edition.	2016
3	Advanced renewable energy sources/ G N Tiwari, R K Mishra/ RSC Publishing/1st edition.	2012
4	Solar Energy: Principles of Thermal Collection and Storage/ S P Sukhatme, J K Nayak/ McGraw Hill Education/ 3rd edition.	2008
5	Electrochemical Energy Advanced Materials and Technologies/ Jiang, San Ping Shen, Pei Kang Sun, Xueliang Wang, Chao-Yang Zhang, Jiujun / Wiley-ISTE/ 1st edition.	2015

Course Name	**:**	**Solar Energy Engineering and Technology**
Course Code	**:**	**MM 2407**
Credits	**:**	**04**
L T P	**:**	**3 1 0**

Course Objectives:

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

1. explain features of solar photovoltaic and solar thermal equipment.
2. outline the technologies that are used to harness the power of solar energy.

Total No. of Lectures – 42

Lecture Wise Breakup		**Number of Lectures**
1	**Solar Energy-Basic Concepts** Introduction, the sun as source of energy, earth radiation spectrum, extraterrestrial and terrestrial radiations, spectral power distribution of solar radiation, depletion of solar radiation, measurement of solar radiation, solar radiation data, solar time, solar radiation geometry, solar day length, extraterrestrial radiation on horizontal surface, empirical equations for estimating terrestrial solar radiation on horizontal surface, solar radiation on inclined plane surface.	8
2	**Fundamentals of Photovoltaic** Introduction, first generation, second generation, third generation, doping, fermi level, p-n junction, p-n junction characteristics, photovoltaic effect, photovoltaic material, basic parameters of solar cell, I–V characteristics, fill factor (FF), maximum power (P_{max}), solar cell efficiency (Z_{ec}), Cell Physics, Energy Bands, More about Electrons and Their Energy, Transport, Generation and Recombination,	8
3	**Solar Photovoltaic Systems** Need for solar cells, components of a solar cell system, solar cell fundamentals, solar cell characteristics, solar cell classification, solar cell technologies, solar cell, module, array construction, single-crystal solar cell module, maximising the solar PV output and load matching, maximum power point tracker, Packing Factor (βc) of PV Module, efficiency of PV module, thin-film PV modules, series and parallel combination of PV modules, balance of system (BOS) components, solar PV systems, solar PV applications.	14
4	**Solar Thermal Systems and Applications** Introduction, solar refrigeration and air conditioning systems, solar collectors, solar water heater, solar passive space heating and cooling systems, solar industrial heating systems, solar cookers, solar furnace, solar greenhouse, solar dryer, solar distillation (desalination of water), solar thermo-mechanical system, thermal analysis of liquid flat plate collector.	12

Course Outcomes:

Student will be able to:

1. understand the concepts of solar photovoltaic system, solar thermal energy conversion system
2. a clear conceptual understanding of technical and commercial aspects of solar power development and management.
3. describe the use of solar energy and the various components used in the energy production with respect to applications.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Non-Conventional Energy Resources/ B.H. Khan/ McGraw Hill Education (India) Private Limited/ 3rd edition.	2016
2	Advanced renewable energy sources/ G N Tiwari, R K Mishra/ RSC Publishing/1st edition.	2012
3	Solar Energy: Renewable Energy and the Environment/Robert Foster, James Witcher, Vaughn Nelson, Majid Ghassemi, Luz Elena Mimbela, Abbas Ghassemi/CRC Press (Taylor & Francis group)/ 1st edition	2009
4	Solar Energy: Principles of Thermal Collection and Storage/ S P Sukhatme, J K Nayak/ McGraw Hill Education/ 3rd edition.	2008

Course Name	**:**	**Failure Analysis of Metals and Alloys**
Course Code	**:**	**MM 2408**
Credits	**:**	**04**
LTP	**:**	**3 0 2**

Course Objectives
At the end of this course the student will be able to: 1. acquire fundamental understanding of the fracture of solid materials. 2. develop detailed understanding of fracture mechanics, creep, and fatigue. 3. acquire basic understanding of the techniques used to perform failure analysis.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
1	**Failure of Metals** Basic reasons for the failure of metals, various types of theories of failure.	3
2	**Review of Basic Concepts of Mechanical Behavior of Materials** Stress-strain curve, engineering design versus failure, types of fracture- ductile fracture, brittle fracture; theoretical fracture stress, Griffith theory, the ductile to brittle transition.	8
3	**Failure modes** Failure in tension, compression, torsion, impact, wear, fatigue, creep, oxidation, corrosion, erosion. metallurgical factors (such as structure, composition, processing) influencing failure mechanism.	9
4	**Techniques of failure analysis** History, data collection, sampling, testing- destructive and non-destructive testing, X-ray diffraction techniques, analysis of results, report preparation, conclusions, recommendation of remedial actions.	8
5	**Quality assurance** A strong link to failure analysis, quality control concept, quality assurance.	4
6	**Case studies** At least one case study representing each failure mode i.e. fatigue, wear, over load, tension and bending etc.	10

S.No.	**List of Experiments**	**No. of Turns**
1	Failure analysis of any sample which fail during to fatigue test	2
2	Failure analysis of any sample which fail during to wear test	2
3	Failure analysis of any sample which fail during to tensile test	2
4	Failure analysis of any sample which fail during to impact test	2
5	Failure analysis of sample which fail due to corrosion	2
6	Case study of the samples collected from the casting unit.	2
7	Case study of the samples collected from the automobile industry	2

Course Outcome
Student will be able to: 1. understand of mechanics analysis for a variety of component. 2. identify the alternate materials and/or service condition that prolong component life.

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

Course Name	**:**	**Degradation of materials**
Course Code	**:**	**MM 2409**
Credits	**:**	**04**
L T P	**:**	**3 0 2**

Course Objectives:
At the end of this course, the student will be able to: 1. understand the fundamental of degradation and corrosion of materials in various environments. 2. solve corrosion problems and design corrosion protection mechanisms.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**Electrolytic Conductance** Electrolytic conductance of aqueous, electrolytic and fused salt solutions-its measurement, transport numbers. electrochemical cells-types of electrochemical cells formed during corrosion. Electrodes potential of half-cell, standard electrodes potential, electrochemical series, Nernst equation, Galvanic series, Potential-pH diagrams.	7
2	**Electrolytic Cell and Electrodeposition** Faraday's law, Current efficiency, Over voltage, Decomposition voltage, Cell voltage, Electro deposition of metals-throwing power, structure of deposited metals. Electrodeposition of Alloys: Control of properties of Electrodeposits e.g. Brightness of electrodeposit, Hydrogen absorption, Mechanical properties, Adhesion and Porosity. Electrodeposition of metal powder and Electrocrystallisation.	7
3	**Electrode Kinetics and Passivity** Electrical double layer, exchange current density, mixed potential theory, different types of polarization, Evan's diagrams, passivity-its curve.	7
4	**Corrosion** Classification of corrosion processes e.g., intergranular corrosion, pitting, stress corrosion etc. their characteristics, metallurgical & other influencing factors and involved corrosion mechanism.	7
5	**Protection Against Corrosion** Protection by design, fabrication and heat treatment procedures, control of environment, protective coatings, cathodic and anodic protection, chromizing, phosphatizing, Zinc and Tin coatings, high temperature oxidation, introduction of corrosion resistant materials.	7
6	**Principles of Electrometallurgical Processes** Electropolishing, electrolytic cutting, machining and grinding, electrocleaning, electroforming, electromining, electrorefining, electromelting and electroetching. decorative applications: rhodium, platinum and gold plating.	7

List of Experiments:		**Number of Turns**
1	To study, perform and observe the following corrosion phenomenon (a) crevice corrosion of stainless steel in chloride solution. (b) pitting of stainless steel.	2

2	Determine corrosion rate of given mild steel samples and study the effect of various factor on it like: (a) concentration of acetic/alkaline solution (b) composition and condition of the sample	3
3	Study the effect of passive film for following systems (a) Al in $CuSO_4$ solution (b) stainless steel in HNO_3	2
4	To perform electrolytic deposition and study effect of parameters.	2
5	To study the concentration polarization phenomenon.	1
6	To perform galvanic corrosion on various metals and prepare galvanic series.	2
7	Effect of heat treatment on corrosion.	1

Course Outcomes:

Student will be able to:

1. apply the concept of electrochemical and electrolytic processes.
2. compare the electrode benefits using Evan's diagram.
3. analyze corrosion phenomenon in a given practical application.
4. design for corrosion protection, minimization.

Suggested Books:

Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Fundamental Aspects of Electro Metallurgy / K. Popov, B. Grgur, S.S. Djokic / Springer US/1st edition	2013
2	Corrosion Engineering / Fontana / Tata McGraw Hill/ 3rd edition	2008
3	Electrochemistry and Corrosion Science / Nestor Perez / Springer US/ 1st edition	2004
4	An Introduction to Electrometallurgy/ Satya Narain, Rajendra Sharan / Standard Publishers Distributors/ 2^{nd} edition	1991

Course Name	**:**	**Heat Treatment of Steels**
Course Code	**:**	**MM 2410**
Credits	**:**	**04**
L T P	**:**	**3 0 2**

Course Objectives
At the end of this course the student will able to: 1. explain the transformation of phase in steels. 2. explain the correlation of time and temperature of treatment with microstructure, apply the TTT/CCT diagram for desired microstructure. 3. design heat treatment cycle for given structural or property requirement.

Total No. of Lecture-42

Lecture wise Breakup		**Number of Lectures**
1.	**Principles of Heat Treatment:** Heat treatment process variables, Formation of austenite, Decomposition of austenite, TTT and CCT, Effect of alloying elements, carbon, grain size on TTT curve, Pearlitic transformation, Bainitic transformation, Martensitic transformation.	12
2.	**Hardenability of Steels:** Hardenability, Jominy end quench test, Effect of parameters viz: alloying elements, carbon content, austenite grain size on hardenability.	4
3.	**Heat Treatment Processes:** Annealing, Normalizing, Spheriodizing, Hardening, Tempering, Austempering, Martempering, Subzero treatment, Patenting.	8
4.	**Thermomechanical Treatment of Steels:** High temperature treatment with low temperature tempering, Low temperature treatment with low temperature tempering, Ausforming, Isoforming, Marstraining, Cryoforming.	6
5.	**Case Hardening:** Carburizing, Cyaniding, Nitriding, Flame hardening, Induction hardening, Measurement of case depth.	5
6.	**Heat Treatment of Commercial Steels** Alloys steels, tools steels, high speeds steels, stainless steels, spring steels, maraging steels,	4
7.	**Defects in Heat Treatment** Soft spots, oxidation and decarburization, overheating and burning of steel, quench cracks, distortion and warping	3

S.No.	**List of Experiments:**	**Number of Turns**
1	Normalizing treatment of steel and comparison of the microstructure with annealed structure.	2
2	To perform hardening and study the quenched structures of steel – quenched in oil, water and brine solution.	2
3	(i)To perform hardening and tempering and study the tempered structures of steel for following condition (a) low temperature tempering. (b) medium temperature tempering. (c) high temperature tempering. (ii) Compare the quenched and tempered structure.	2
4	To perform cold working followed by recrystallization and study the recrystallization behaviour of Al/ Fe/ Cu.	2
5	To carry out age hardening of non ferrous alloys. (Al-Cu alloy 2024, Al-Zn-Mg-Cu 7075	2
6	Determination of hardenability of steels using Jominy End Quench Test	2
7	To perform the Carburizing treatment and to study the effect of time on the Case depths of carburized steel.	2

Course Outcomes:
Student will be able to: 1. establish Heat Treatment – Process – Structure – Property correlation 2. design Heat Treatment to meet a property requirement for engineering application.

Suggested Books		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1.	Heat Treatment: Principles and Techniques/Ashok Rajan, T.V. Sharma, C.P. Sharma /PHI Learning Private Limited/2nd edition	2011
2.	Principle of Heat treatment of Steels/ R.C. Sharma/ New Age International (P) Limited	2018

Course Name	**:**	**Modelling and Simulation in Metallurgy**
Course Code	**:**	**MM 2411**
Credits	**:**	**04**
L T P	**:**	**3 0 2**

Course Objectives:

At the end of the course, student will be able to understand the effect of certain parameters on metallurgical processes with the help of modeling software and evaluate engineering problems.

Total No. of Lectures – 28

Lecture Wise Breakup		**Number of Lectures**
1	**Introduction** Introduction to modeling & simulation, basic principles of modeling & simulation, mathematical and physical basis of modelling & its methodology, basic approaches and techniques of modelling & simulation, examples of metallurgical and materials processes, mass and energy balances, and simultaneous solutions. applications of simulation in metallurgy system.	10
2	**Solution Techniques For Design Optimization Problem** Introduction, single variables, optimality criteria, bracketing methods: Exhaustive search method. Bounding phase method. Region elimination methods Interval halving method. Fibonacci Search method, golden section method, point estimation methods and gradient based methods: Newton raphson method, Bisection method, Secant method, cubic search method. Multi variables Optimization, Unidirectional search, direct search methods, gradient based methods, liner programming methods for optimum design.	12
3	**Analysis of Simulation Data** Review of transport phenomena, differential equations and numerical methods, concept of physical domain and computational domain, assumptions and limitations in numerical solutions, input data analysis, verification and validation of simulation models, output data analysis, molecular dynamics and Monte-Carlo simulations, comparison and selection of simulation languages, design and evaluation of simulation experiments.	12
4	**Case Studies** Computer simulation of casting processes: prediction of mould filling, solidification, residual stress and microstructure evolution and their role in design of casting, gating and risering. mathematical modelling from iron and steel making such as modelling of mold design, blast furnace, basic oxygen furnace, electric arc furnace, ladle furnace, ingot casting, continuous casting, forging, electroslag refining, sheet metal forming, ladle furnace, tundish, continuous casting etc.	8

Lab Experiments	**No. of Hours**
Lab component comprises project assigned by the course coordinator.	28

Course Outcomes:

Student will be able to:

1. understand the importance and necessity of simulation and modeling studies in metallurgical processes.
2. apply the theoretical background on simulation and modeling of metallurgical processes.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Secondary Steel Making: Principles and Applications/ A K Ghosh/ CRC press	2001
2	Alloy Modeling and Design/ G M Stocks, P E A Turchi/ The Metals Society, AMIE, USA	1994
3	Modeling of Casting, Welding, and Advanced Solidification Process/ T S Piwonoka, V Vollen, Katgerman/ TMS-AIME, USA/ 4th edition	1993
4	Numerical Heat Transfer and Fluid Flow/ S V Patankar/ Washington DC	1980

Open Elective Courses

Course Name	**:**	**Surface Engineering**
Course Code	**:**	**MM 6001**
Credits	**:**	**04**
LTP	**:**	**3 1 0**

Course Objectives
At the end of this course the student will be able to: 1. describe surface phenomenon of the material like friction, corrosion, surface treatments. 2. apply concepts to design modification of solid surfaces.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
1	**Introduction** Role of surface on various engineering phenomena, technological properties of surfaces, need for modification of surfaces.	3
2	**Additives and Tribology** Wetting and dispersing agents, viscosity control, anti-skin, dryers, mating agents, thyrotrophic agents, mar resistance, anti-foam, anti-settling, desiccants, anti-rust, protective colloids, biocide, adhesion promoter, UV-stabilizers, plasticizers, etc. surface dependent engineering properties, viz., wear, friction, corrosion, fatigue, reflectivity, emissivity, etc. common surface initiated engineering failures, mechanism of surface degradation, importance and necessity of surface engineering, classification and scope of surface engineering in metals, ceramics, polymers and composites, tailoring of surfaces of advanced materials.	14
3	**Characterization Techniques** Film thickness measurements using optical techniques, corrosion testing of coatings, evaluation of mechanical properties of thin films, microstructural characterization of coatings and thin films, wear and erosion testing of coatings.	7
4	**Plating Processes** Fundamentals of electroplating, electrodeposition from plating baths, electroless plating, mentalliding, selective plating, hard anodizing, other plating processes, applicability of plating for wear resistance.	6
5	**Surface Coatings** Dip, barrier and chemical conversion coatings, vacuum and controlled- atmosphere coating.	6
6	**Surface Hardening** Flame hardening, induction hardening, electron beam hardening, laser hardening, iron implantation.	6

Course Outcome
Student will be able to: 1. apply the surface phenomenon to various metallurgical processes. 2. analyze complex service failure problems and suggest the solutions.

Suggested books		
S. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Surface Treatment of Materials for Adhesive Bonding/ Sina Ebnesajjad and Cyrus Ebnesajjad/ William Andrew.	2014
2	Modern Surface Technology/ Friedrich-Wilhelm Bach, Andreas Laarmann, Thomas Wenz/ Wiley-VCH	2006
3	Introduction to Tribology /Bharat Bhushan/John Wiley & Sons	2002

4	Surface Engineering of Metals: Principles, Equipment, Technologies/ Tadeusz Burakowski Tadeusz Wierzchon: /CRC Press	1998

Course Name	**:**	**Failure Analysis of Metals and Alloys**
Course Code	**:**	**MM 6002**
Credits	**:**	**04**
LTP	**:**	**3 0 2**

Course Objectives
At the end of this course the student will be able to: 4. acquire fundamental understanding of the fracture of solid materials. 5. develop detailed understanding of fracture mechanics, creep, and fatigue. 6. acquire basic understanding of the techniques used to perform failure analysis.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
1	**Failure of Metals** Basic reasons for the failure of metals, various types of theories of failure.	3
2	**Review of Basic Concepts of Mechanical Behavior of Materials** Stress-strain curve, engineering design versus failure, types of fracture- ductile fracture, brittle fracture; theoretical fracture stress, Griffith theory, the ductile to brittle transition.	8
3	**Failure modes** Failure in tension, compression, torsion, impact, wear, fatigue, creep, oxidation, corrosion, erosion. metallurgical factors (such as structure, composition, processing) influencing failure mechanism.	9
4	**Techniques of failure analysis** History, data collection, sampling, testing- destructive and non-destructive testing, X-ray diffraction techniques, analysis of results, report preparation, conclusions, recommendation of remedial actions.	8
5	**Quality assurance** A strong link to failure analysis, quality control concept, quality assurance.	4
6	**Case studies** At least one case study representing each failure mode i.e. fatigue, wear, over load, tension and bending etc.	10

S.No.	**List of Experiments**	**No. of Turns**
1	Failure analysis of any sample which fail during to fatigue test	2
2	Failure analysis of any sample which fail during to wear test	2
3	Failure analysis of any sample which fail during to tensile test	2
4	Failure analysis of any sample which fail during to impact test	2
5	Failure analysis of sample which fail due to corrosion	2
6	Case study of the samples collected from the casting unit.	2
7	Case study of the samples collected from the automobile industry	2

Course Outcome
Student will be able to: 3. understand of mechanics analysis for a variety of component. 4. identify the alternate materials and/or service condition that prolong component life.

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

Course Name	**:**	**Materials Science and Engineering**
Course Code	**:**	**MM 6003**
Credits	**:**	**04**
L T P	**:**	**3 1 0**

Course Objectives:

At the end of this course the student will be able to know the concepts of atomic bonding, crystal structures, imperfections, diffusion, mechanical properties, electron energy, and dislocations as related to processing and performance of engineering material.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**Introduction** Historical perspective, Scope of Materials Science and engineering, Geometry of crystals, Structure determination by X-Ray Diffraction, Atomic structure and chemical bonding,Structure of solids	10
2	**Imperfections in Atomic and Ionic Arrangements** Point defects, Dislocations, Significance of Dislocations, Influence of Crystal structure, Surface defects, Importance of defects	4
3	**Phase Diagrams** Phase rule, Single component systems, Binary Phase diagrams, Microstructural changes during cooling, The lever rule, Some typical phase diagrams, Other applications of Phasediagrams	4
4	**Diffusion in Solids** Applications of Diffusion, Stability of atoms and ions, Mechanism for Diffusion, Activation energy for Diffusion, Rate of Diffusion (Fick's First Law), Factors affecting Diffusion, Composition Profile (Fick's Second Law), Diffusion and Materials Processing	4
5	**Solidification** Nucleation, Applications of Controlled Nucleation, Growth mechanisms, Solidification time and Dendrite size, Cast structure, Solidification defects, Solidification of Polymers and Inorganic glasses	6
6	**Elastic, Anelastic and Viscoelastic Behaviour** Atomic model of elastic behaviour, The modulus as a parameter in design, Rubber-likeelasticity, Relaxation processes, Spring-Dashpot model	6
7	**Mechanical Behaviour of Materials** Plastic deformations and creep in crystalline materials, Fracture	4
8	**Electronic and Magnetic Behaviour of Materials** Conductivity of metals and alloys, Superconductivity, Semiconductors and their applications, Insulators and Dielectrics, Classification of magnetic materials, Magnetization, Permeability and magnetic field, Applications of magnetic materials.	4

Course Outcomes:

The student will be able to:

1. develop structure-processing-properties co-relation of materials.
2. describe various phenomena based on the concepts of solidification, diffusion, mechanical behaviour of materials and compare characteristics of different types of materials.

Suggested Books:

Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Materials Science and Engineering-A First course/ V Raghavan/PHI	2013
2	Materials Science and Engineering, an Introduction/William D. Callister/ John Willey and Sons Inc. Singapore.	2007
4	The Science and Engineering of Materials, Donald R Askeland & Pradeep P Phule/ Cengage Learning	2006

Course Name	**:**	**Materials Characterization Techniques**
Course Code	**:**	**MM 6004**
Credits	**:**	**04**
L T P	**:**	**3 1 0**

Course Objectives
At the end of this course the student will be able to: 3. understand the fundamental concepts of different characterization methods. 4. analyze characterization methods for the determination of the result of composition, structure and properties of materials.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**Macroscopic Examination** Meaning/importance/need/role of examination of material, Importance & scope of macro-etching, Sulphur/Phosphorus/Oxide Printing, Flow Lines.	4
2	**Metallography** Principle, Construction and working of metallurgical microscope, Various properties of microscope objectives, Defects in lenses & their remedies, estimation of grain size, grain boundary area, relevance of light microscopy ideas to electron microscopy.	6
3	**Electron Microscopy** Scanning Electron Microscope (SEM): Principle, construction and operation of SEM, Interaction of electron beam with specimen, Study of fractured surfaces, Energy and wavelength dispersive spectroscopy, Field Emission Scanning Electron Microscope (FESEM). Transmission Electron Microscope (TEM): Principle, construction and operation of TEM, Interaction of electrons with specimen, Preparation of specimens, Selected area diffraction, Indexing of diffraction patterns.	8
4	**X-Ray Diffraction Techniques** Bragg's condition of diffraction, X-ray scattering, application of X-ray diffraction- phase identification, estimation of crystallite size, residual stress, X-ray Fluorescence (XRF).	6
5	**Spectroscopy Techniques** UV-Vis Spectroscopy, FTIR Spectroscopy Analysis, Atomic Absorption Spectroscopy, X-ray Photoelectron Spectroscopy (XPS).	7
6	**Thermal Analysis Techniques** Principles of Differential Scanning Calorimetry (DSC), Differential Thermal Analysis (DTA), Dilatometry, Thermogravimetric Analysis (TGA).	7
7	**Surface Characterization Techniques** Scanning Probe Microscope, Atomic Force Microscope (AFM), Scanning Tunneling Microscopy (STM).	4

List of Experiments:	**Number of Turns**
To determine the elements present in different alloys using Metascope.	2
To prepare and standardize a sodium hydroxide solution and determine the molar concentration of a strong acid	2
Destructive testing-hardness, impact test etc. and Non-Destructive testing of samples (Dye penetrate test) etc.	2
Macroscopic examination of metals and alloys-segregation, Flow lines etc	2
To detect crack using Ultrasonic Flaw detector etc. using wear friction monitor.	2
Friction and wear study of different metals and alloys.	1

To study and perform Fatigue Test	1
To study the SEM and to examine the given sample	1
To find the copper content in the given sample by electrolytic deposition	1

Course Outcomes

Student will be able to:

4. understand the principle of materials characterization techniques.
5. apply of characterization techniques for different applications.
6. analyze and interpret the results of different characterizations required for the characteristics of materials.

Suggested books

S. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Materials Characterization: Introduction to Microscopic and Spectroscopic Methods / Y. Leng / John Wiley & Sons/ 1st edition.	2013
2	Spectroscopy of Organic Compounds / P S Kalsi / New Age International /6th edition.	2007
3	Elements of X-Ray Diffraction / B. D. Cullity, S.R. Stock / Pearson / 3rd edition.	2001
4	Electron Microscopy and Analysis / P.J. Goodhew, J. Humphreys, R Beanland / Taylor and Francis / 3rd edition.	2000
5	Principles of Metallographic Laboratory Practice / G L Kehl / McGraw-Hill / 1st edition/	1980

Course Name	**:**	**Heat Treatment of Steels**
Course Code	**:**	**MM 6005**
Credits	**:**	**04**
L T P	**:**	**3 0 2**

Course Objectives
At the end of this course the student will able to: 4. explain the transformation of phase in steels. 5. explain the correlation of time and temperature of treatment with microstructure, apply the TTT/CCT diagram for desired microstructure. 6. design heat treatment cycle for given structural or property requirement.

Total No. of Lecture-42

Lecture wise Breakup		**Number of Lectures**
1.	**Principles of Heat Treatment:** Heat treatment process variables, Formation of austenite, Decomposition of austenite, TTT and CCT, Effect of alloying elements, carbon, grain size on TTT curve, Pearlitic transformation, Bainitic transformation, Martensitic transformation.	12
2.	**Hardenability of Steels:** Hardenability, Jominy end quench test, Effect of parameters viz: alloying elements, carbon content, austenite grain size on hardenability.	4
3.	**Heat Treatment Processes:** Annealing, Normalizing, Spheriodizing, Hardening, Tempering, Austempering, Martempering, Subzero treatment, Patenting.	8
4.	**Thermomechanical Treatment of Steels:** High temperature treatment with low temperature tempering, Low temperature treatment with low temperature tempering, Ausforming, Isoforming, Marstraining, Cryoforming.	6
5.	**Case Hardening:** Carburizing, Cyaniding, Nitriding, Flame hardening, Induction hardening, Measurement of case depth.	5
6.	**Heat Treatment of Commercial Steels** Alloys steels, tools steels, high speeds steels, stainless steels, spring steels, maraging steels,	4
7.	**Defects in Heat Treatment** Soft spots, oxidation and decarburization, overheating and burning of steel, quench cracks, distortion and warping	3

S.No.	**List of Experiments:**	**Number of Turns**
1	Normalizing treatment of steel and comparison of the microstructure with annealed structure.	2
2	To perform hardening and study the quenched structures of steel – quenched in oil, water and brine solution.	2
3	(i)To perform hardening and tempering and study the tempered structures of steel for following condition (d) low temperature tempering. (e) medium temperature tempering. (f) high temperature tempering. (ii) Compare the quenched and tempered structure.	2
4	To perform cold working followed by recrystallization and study the recrystallization behaviour of Al/ Fe/ Cu.	2
5	To carry out age hardening of non ferrous alloys. (Al-Cu alloy 2024, Al-Zn-Mg-Cu 7075	2
6	Determination of hardenability of steels using Jominy End Quench Test	2
7	To perform the Carburizing treatment and to study the effect of time on the Case depths of carburized steel.	2

Course Outcomes:
Student will be able to: 1. establish Heat Treatment – Process – Structure – Property correlation 2. design Heat Treatment to meet a property requirement for engineering application.

Suggested Books		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1.	Heat Treatment: Principles and Techniques/Ashok Rajan, T.V. Sharma, C.P. Sharma /PHI Learning Private Limited/2nd edition	2011
2.	Principle of Heat treatment of Steels/ R.C. Sharma/ New Age International (P) Limited	2018

Course Name	**:**	**Nanomaterials Technology and Applications**
Course Code	**:**	**MM 6006**
Credits	**:**	**04**
L T P	**:**	**3 1 0**

Course Objectives

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

1. impart knowledge about the fundamental concepts relevant to nanomaterials.
2. understand synthesis methods to produce nanomaterials.
3. apply the fundamental concepts of nanomaterials in different applications.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**Science and Technology of Nanomaterials** Introduction to miniaturization, fundamentals of nanoscience and nanotechnology, size dependence of properties, bulk to nano transition, carbon nanostructures, quantum wells, quantum wires, and quantum dots, mechanical, electronic and optical properties at nano level, nanostructured materials.	10
2	**Synthesis of Nanocrystalline Powders** Gas phase synthesis, plasma chemical technique, precipitation from colloidal solutions, co-precipitation & sol-gel method, thermal decomposition and reduction, milling and mechanical alloying, synthesis by detonation and electric explosion, ordering in non-stoichiometric compounds.	9
3	**Preparation of Bulk Nanocrystalline Materials** Compaction of nanopowders, Film and coating deposition, crystallization of amorphous alloys, Severe plastic deformation, disorder-order transformations.	8
4	**Characterization of Nanosystems** X-ray diffraction, Scanning Electron Microscopy, Scanning tunneling microscopy, Electron microscopy, X-ray absorption spectroscopy, Photoelectron emission spectroscopy, particle size distribution by BET & DLS methods.	9
5	**Nano Materials Applications** Nanotubes, nanowires, and nanodevices applications such as: Light-emitting diodes (LEDs), laser diodes, single-electron transistors, photonic crystals, photodetectors, memory devices etc.	6

Course Outcomes

The students will be able to

1. understand the properties, structure and classification of nanomaterials.
2. understand and account for different approaches used for synthesis of nanomaterials
3. apply the fundamental and technical aspects of nanomaterial for different applications.

Suggested books

S. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Nanomaterials Synthesis: Design, Fabrication and Applications/ Y. B. Pottathara, S.Thomas, N. Kalarikkal, Y. Grohens, V. Kokol/ Elsevier/ 1st edition.	2019
2	Nanomaterials: Synthesis, Characterization, and Applications/ A. K. Haghi, Ajesh K. Zachariah, N. Kalarikkal/ CRC Press	2013
3	Introduction to nanotechnology/Charles P. Poole and Frank J Owens/ Wiley Interscience	2003
4	Nanostructured Materials: Processing Properties and Applications /Carl C. Koch/ Noyes Publications	2002

Course Name	**:**	**Energy Storage Materials**
Course Code	**:**	**MM 6007**
Credits	**:**	**04**
L T P	**:**	**3 0 2**

Course Objectives:
At the end of this course the student will be able to: 1. implement the basic principles of functioning of devices for electrochemical conversion and storage. 2. acquaint with physical-chemical mechanisms for the devices during their operation.

Total No. of Lectures – 42

Lecture Wise Breakup		**Number of Lectures**
1	**Introduction** Ragone charts, necessity of energy storage, specifications of energy storage devices, self-discharge time, unit size, efficiency, cycle life, specific energy, energy density.	2
2	**Energy Storage Methods** Mechanical energy storage, compressed air energy storage, flywheel storage, secondary battery storage, lead–acid battery, limitations of lead–acid storage batteries, sulfation, acid stratification, valve regulated lead acid battery, nickel–cadmium (Ni–Cd) battery, nickel–metal hydride (Ni–MH or Ni–MH) battery, lithium–ion battery (LIB), lithium–polymer battery, sodium–sulphur battery, ZEBRA battery, flow batteries, vanadium redox flow battery, polysulphide bromide battery, zinc bromide flow battery.	7
3	**Materials For Supercapacitor Applications** Supercapacitor-an emerging electrical energy storage device, historical perspective, supercapacitors and batteries as electrical energy storage devices-a comparison, faradaic and non-faradaic processes, electric double layer, helmholtz model, gouy-Chapman or diffuse model, types of capacitors, electrochemical double layer capacitors (EDLCs), pseudocapacitors, hybrid capacitors, composite supercapacitors, asymmetric supercapacitors, battery-type supercapacitors, carbon materials in supercapacitors, carbon-based hybrid supercapacitors, perspectives on carbon for SC electrodes, perspectives on transition metal oxides for SC electrodes, electrolyte materials for supercapacitors, capacitance, energy density and power density, equivalent series resistance, cycle life, self-discharge rate, thermal stability, electrolyte performance validation using supercapacitor test cells, transient techniques, constant current charge or discharge, constant potential charge or discharge, constant power charge or discharge, leakage current and self-discharge behaviour.	12
4	**Fuel Cells and Types** Development stages and relative performances of various fuel cells, fuels for fuel cells, efficiency of a fuel cell, characteristics of fuel cell, fuel cell power plant, present status, environmental effects, phosphoric acid fuel Cell (PAFC), alkaline fuel Cell (AFC), polymer electrolyte membrane fuel cell (PEMFC), direct methanol fuel cell (DMFC), molten carbonate fuel cell (MCFC), solid oxide fuel cell (SOFC).	14
5	**Hydrogen as Energy Carrier** Properties of hydrogen, production, electrolysis of water, mechanism of hydrogen Evolution reaction, overpotential, Tafel Slope, electrochemical active surface area and current normalization, number of active sites and turnover frequency, Faradic Efficiency, long cycle life, thermolysis of water, biophotolysis, storage, delivery, conversion.	7

Lab Experiments	**No. of Hours**
Lab component comprises project work assigned by the course coordinator.	28

Course Outcomes:
Student will be able to: 1. understand the working principles of modern devices for energy storage and conversion. 2. explain the limitations, existing issues and wider aspect concerning commercialization of advanced devices.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Materials for Supercapacitor Applications/ M. Aulice Scibioh, B. Viswanathan/ Elsevier/1st edition.	2020
2	Non-Conventional Energy Resources/ B.H. Khan/ McGraw Hill Education (India) Private Limited/ 3rd edition.	2016
3	Electrochemical Energy Advanced Materials and Technologies/ Jiang, San Ping Shen, Pei Kang Sun, Xueliang Wang, Chao-Yang Zhang, Jiujun / Wiley-ISTE/ 1st edition.	2015

Course Name	**:**	**Bio-materials**
Course Code	**:**	**MM 6008**
Credits	**:**	**04**
L T P	**:**	**3 0 2**

Course Objectives:

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

1. understand the fundamentals of biomaterials.
2. emphasis on understanding of biomaterials, their synthesis techniques, their behavior under loadings and application in design for broken or failed parts of the human body.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**Engineered Materials in Medical Applications** Basic understanding on the engineering and processing aspects of biomaterials used in medical applications, biocompatible, bioactive, and biodegradable materials, metallic implants, bioceramic, polymeric hydrogel, composites in biomedical applications.	12
2	**Tissue -Biomaterial Interactions** Biocompatibility of biomaterials: protein structure, interaction of proteins with synthetic materials; characterization of cell material interactions; inflammatory responses; acute inflammation, chronic inflammation, foreign body response, assessment of material performance.	12
3	**Implantable Medical Devices:** Current progress in bio medical devices application of biomaterials in medicine, biology, and artificial organs, examples of medical devices such as drug delivery, regenerative medicine, etc.	10
4	Case Studies on advance applications of Biomaterials	8

List of Experiments	**No. of Turns**
Lab component comprises project work assigned by course coordinator.	**28 Hrs**

Course Outcomes:

Student will be able to

1. identify the biomaterials and their production.
2. describe the application of biomaterials in living tissues.

Suggested Books:

Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Biomaterials Science and Engineering/ R Pignatello/ Janeza Trdine	2011
2	Biomaterials: An Introduction / J Park, R S Lakes/ Springer	2007

Course Name	**:**	**Metal Casting Technology**
Course Code	**:**	**MM 6009**
Credits	**:**	**04**
L T P	**:**	**3 0 2**

Course Objectives:
All the end of this course, the student will be able to 5. explain basics of metal casting, its types, designing patterns cores and molding. 6. describe sand casting process, foundry melting furnaces. 7. design for feeding and gating. 8. establish structure property correlation with casting process and casting defects.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**Introduction** Casting as a process of Manufacturing, History of casting practices, Basic steps involved in the making of sand casting, Process chart of casting, Layout of a foundry, The features of casting problem; a survey and scope of foundry industry.	3
2	**Patterns and Core Boxes** Types, allowances, functions, materials used for pattern/core making.	2
3	**Molding Processes** Molding practices, Odd side, three-part, loam, sweep & pit molding, stack molding.	2
4	**Molding Machines, Equipment and Mechanization** Machines for sand mixing and preparation of moulds, muller, jolting, squeezing, jolt-squeezing, slinging, blowing and shooting machines; their functions & characteristics.	4
5	**Molding Sands** General properties of molding sands, basic ingredients, additives, testing of molding sands – moisture content, strength/GCS, permeability, mold hardness, clay content, AFS no.	4
6	**Cores and Core Materials** Core making and machine used, various core making processes, venting, core assembly, core setting, core prints and chaplets, Chills, core knock out and disposal, testing of core sand and core coatings, cores and casting defects, Core dryer and Air circulation.	4
7	**Solidification of Metals** Freezing of pure metals and alloys, shrinkage, fluidity and spiral test, hot tearing and cracking, inoculation, metal filtration.	3
8	**Pouring and Feeding of Casting** Pouring ladles, gating system, progressive and directional solidification, types of gates, design of gating system, fluid flow, factors involved in gating design, pouring time, choke area, sprue-runner-gate ratios, Riser-theoretical considerations, function, shape, location, types.	5
9	**Melting of Metals** Cupola furnace: construction and operation, coke bed height, various types of cupolas-cold/hot/divided blast, coke bed and stack gases, melting rate, combustion and melt temperature, induction furnace.	4
10	**Casting Design** Factors affecting casting design, common design rules.	2

11	**Shakeout, Fettling, Cleaning and Inspection of Casting**	2
12	**Casting Defects and Diagnosis by NDT** Inclusions blow holes, pin holes and porosity, shrinkage, misrun, cold shut and cold lap, metal penetration, scab and rat tails, parting line shift and mismatch, sand drops and mold brake, defect diagnosis by radiography, ultrasonic, magnetic methods and eddy current techniques.	5
13	**Energy Conservation and Environment Protection**	2

List of Experiments:		**Number ofTurns**
1	To study the charge and heat balance of the cupola/arc and induction melting furnaces.	3
2	Sand Testing ix. To study the size, shape and distribution of pure dry silica sand sample. x. To find out the AFS number of given sand sample. xi. To find out the clay content in the given sand sample by washing. xii. To find out the active and dead clay content in the given sand sample. xiii. To find out the permeability of the given moulding sand. xiv. To study the effect of clay and water content on strength (gcs) of moulding sand by preparing sands of different clay and moisture contents. xv. To find out the water content by conventional and rapid moisture teller in the given sand sample. xvi. To find out the mold and core hardness using mould and core hardness testers.	6
3	iii. To prepare a green sand mould in foundry workshop. iv. To melt and cast ferrous and non-ferrous metals.	3
4	To study the layout of an industrial casting unit.	1
5	To study the various casting defects by visiting a nearby foundry.	1

Course Outcomes:

Student will be able to:

1. apply fundamentals of sand and other castings.
2. apply theory of solidification on cast metals and alloys.
3. design moulds and pattern for making castings.
4. analyze the economics, environment, health and safety aspects for various applications.

Suggested Books:

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

Course Name	**:**	**Mechanical Behaviour of Materials**
Course Code	**:**	**MM 6010**
Credits	**:**	**04**
L T P	**:**	**3 1 0**

Course Objectives:

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

4. use the concepts of stress and strain to explain the elastic and plastic behaviour of the material.
5. relate the mechanical behaviour of materials to dislocation theory and presence of surface defects and volume defects. design a process based on strengthening mechanisms for a given application.
6. apply mechanisms of material failures fracture, fatigue and creep for failure analysis.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**Concepts of Stress and Types of Stress** Concepts of Stress and types of Stresses, Concepts of Strain and types of Strain, Units ofstress and other quantities.	2
2	**Elastic, Anelastic and Viscoelastic Behaviour** Elastic behaviour: Atomic model of elastic behaviour, The modulus as a design parameter,Rubber like elasticity. Anelastic Behaviour: Relaxation Processes. Viscoelastic behaviour: spring dashpot models.	4
3	**Stress and Strain Relationships for Elastic Behaviour** Description of stress at a point, state of stress in two dimensions, state of stress in three dimensions, Description of strain at a point, Hydrostatic component of stress, Elastic Stress - Strain relations, Calculation of Stresses from Elastic Strains, Strain Energy, Anisotropyof Elastic behaviour, Stress Concentration	3
4	**Plasticity of Materials** The Flow Curve, True Stress and True Strain, Yielding and plastic flow, Dislocations thebasis for yield.	2
5	**Dislocation Theory** Dislocation during growth of crystals; Theoretical and observed yield stress, geometry of dislocations. Burgers Vector, Right hand convention - Types of dislocations loops and motion out of crystals strain energy of mixed dislocation two hard particles; simple relationship for forces between dislocation vector notation of dislocation in crystal systems; combination of dislocation stacking fault energy; motion of extended dislocation; construction Frank dislocation; Cross slip; double jump; Geometrical characteristics of dislocation; Interaction of dislocations (simple cases); Motion of kinked and Jogged dislocation; Non conservation method Motion creation of vacancies, Frank Read source, Sessile dislocations Lomer-Cotrell, stair-rod; width of dislocation; Pile up of dislocation, solid solution strengthening anti-phase boundary; Yield unit; Luder bands.	14
6	**Micro-Plasticity of Crystals** Slip planes and slip directions, r esolved shear stress, strain hardening and recovery ofsingle crystals, Twinning, Grain boundary sliding and diffusional creep.	5
7	**Plastic Deformation** Grain boundaries, Strain hardening, strain aging, The tensile stress strain curve:temperature dependence, strain rate, strain rate and temperature, Creep.	3
8	**Cold Worked Structure** Recovery, Recrystallization and Grain Growth.	2
9	**Strengthening Mechanisms** Cold working and annealing: Recovery, Recrystallization and Grain Growth, dynamic recovery, strain/ work hardening, solute hardening or solid solution strengthening, precipitation hardening, dispersion hardening, grain refinement.	3
10	**Fracture** Types of fracture- ductile fracture, brittle fracture; Theoretical fracture stress, Griffith theory, Orowan Theory, Comparison with equation based on stress concentration Crack velocities; Inglis equation; Dislocation model of crack nucleation Zener model, Cotrell- Hull model in BCC metals. Fracture toughness, The ductile to brittle transition. Methods of protection against fracture- surface treatment, compressive stresses.	4

Course Outcomes:
The student will be able to: 1. explain concepts of stress and strain, analyze dislocation interactions with other defects. 2. To apply dislocation theory to explain various plastic deformation phenomena, strengthening mechanisms and fracture mechanisms. 3. Solve numerical problems based on this course and engineering applications.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1.	Dislocations and mechanical Behaviour of materials/ M.N.Shetty/ PHI Learning Pvt. Ltd.	2013
2.	Mechanical Behaviour of Materials/ Marc André Meyers, Krishan Kumar Chawla/Cambridge University Press	2009
3.	Mechanical Metallurgy/G.E Dieter adapted by David Bacon/ McGraw-Hill Book Company	1988
4	The structure and properties of materials, volume III, Mechanical Behaviour/H.E Hayden, William G Moffatt, John Wulff /Willey Eastern Ltd.	1986